

DRAFT

Treatability Study in Support of Remediation by Natural Attenuation for Groundwater at Site LF-06



**Columbus Air Force Base
Columbus, Mississippi**

Prepared For

**Air Force Center for Environmental Excellence
Technology Transfer Division
Brooks Air Force Base
San Antonio, Texas**

and

**Columbus Air Force Base
Columbus, Mississippi**

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

20000831 044

August 1997



Walton, Norman

From: Hansen, Jerry E, Mr, HQAFCEE [Jerry.Hansen@HQAFCEE.brooks.af.mil]

Sent: Tuesday, August 08, 2000 10:16 AM

To: 'nwalton@dtic.mil'

Subject: Distribution statement for AFCEE/ERT reports

Norman, This is a followup to our phone call. The eight boxes of reports you received from us are all for unlimited distribution. If you have any questions, you can contact me at DSN 240-4353.

08/08/2000

DRAFT

DRAFT

**TREATABILITY STUDY IN SUPPORT OF
REMEDATION BY NATURAL ATTENUATION FOR GROUNDWATER AT
SITE LF-06**

at

**COLUMBUS AIR FORCE BASE
COLUMBUS, MISSISSIPPI**

AUGUST 1997

Prepared for:

**AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
BROOKS AIR FORCE BASE
SAN ANTONIO, TEXAS**

and

**COLUMBUS AIR FORCE BASE
COLUMBUS, MISSISSIPPI**

Prepared by:

**PARSONS ENGINEERING SCIENCE, INC.
1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290**

EXECUTIVE SUMMARY

This report presents the results of a treatability study (TS) performed by Parsons Engineering Science, Inc. (Parsons ES) at Site LF-06, Columbus Air Force Base, Mississippi, to evaluate remediation by natural attenuation (RNA) of dissolved fuel-hydrocarbons and chlorinated aliphatic hydrocarbons (CAHs) in groundwater. The TS focused on the fate and transport of dissolved CAHs, particularly trichloroethene (TCE), chlorobenzene (CB), and vinyl chloride (VC); however, petroleum hydrocarbons [including benzene, toluene, ethylbenzene, and xylenes (BTEX)] also are present in site groundwater and were considered. The site history and the results of the soil and groundwater investigations conducted previously also are summarized in this report.

Comparison of CAH, BTEX, electron acceptor, and biodegradation byproduct isopleth maps for LF-06 provides strong qualitative evidence of biodegradation of dissolved CAHs. These geochemical data strongly suggest that reductive dehalogenation of dissolved CAHs is occurring at the site as microbes utilize natural organic carbon, BTEX, and other fuel hydrocarbons as substrates. Patterns observed in the distribution of CAHs, daughter products of CAHs, electron acceptors, and biodegradation byproducts also suggest that biotic and abiotic dehydrohalogenation may also be acting to reduce the concentration of CAHs dissolved in site groundwater. Field-scale first-order decay rates computed using data from LF-06 included a total BTEX biodegradation rate of 0.053 day^{-1} , a chlorobenzene biodegradation rate of 0.010 day^{-1} , and a total chlorinated ethene dechlorination rate of 0.0035 day^{-1} . The equivalent half-lives are 0.35 years, 0.19 years, and 0.54 years, respectively.

An important component of this study was an assessment of the potential for contamination in groundwater to migrate from the source areas to potential receptor exposure points (i.e., off-Base locations to the south and west of Site LF-06). An analytical model was used to evaluate the fate and transport of dissolved CAHs and

BTEX in the shallow groundwater under the influence of advection, dispersion, sorption, and biodegradation. Input parameters for the model were obtained from site data collected by Parsons ES. Model parameters that were not measured at the site were estimated using reasonable literature values.

The results of this demonstration suggest that RNA of dissolved CAHs and BTEX contamination is occurring at Site LF-06; furthermore, the estimated rates of biodegradation, when coupled with sorption, dispersion, and dilution, should be sufficient to reduce and maintain dissolved contamination concentrations to levels below current regulatory guidelines long before potential downgradient or off-site receptors could be adversely affected. Conservative modeling suggests that under current conditions, the concentrations of the groundwater contaminant plume will drop below MCLs within, at most, 1,000 feet downgradient from the edge of the landfill. Future site activities are not anticipated to change, and the risk to any Base personnel would be minimal, provided institutional controls for soil and groundwater are maintained. Institutional controls such as restrictions on shallow groundwater use at the site would prevent completion of receptor exposure pathways until RNA is complete. The Air Force therefore recommends implementation of RNA and long-term monitoring (LTM) with institutional controls.

To verify model predictions, and to ensure that the selected technologies are meeting objectives, the Air Force recommends using 10 LTM wells and 4 sentry wells to monitor the long-term migration and degradation of the dissolved hydrocarbon plume. In addition to analyses used to verify the effectiveness of RNA, the groundwater samples should be analyzed for CAH and BTEX compounds by US Environmental Protection Agency (USEPA) Method SW8260. If data collected under the LTM program indicate that the selected remedial system is not sufficient to reduce BTEX concentrations at downgradient well locations to levels considered protective of human health and the environment, additional corrective actions may be required to remediate groundwater at the site.

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	ES-1
ACRONYMS AND ABBREVIATIONS	vii
SECTION 1 - INTRODUCTION.....	1-1
1.1 Scope and Objectives	1-2
1.2 Facility Background.....	1-5
SECTION 2 - SITE CHARACTERIZATION ACTIVITIES	2-1
2.1 Drilling, Soil Sampling, and Monitoring Point Installation	2-1
2.1.1 Geoprobe® Operation	2-2
2.1.1.1 Pre-Drilling Activities	2-2
2.1.1.2 Equipment Decontamination Procedures.....	2-2
2.1.1.3 Drilling and Soil Sampling.....	2-5
2.1.2 Temporary Monitoring Point Installation	2-7
2.1.2.1 Monitoring Point Materials Decontamination	2-7
2.1.2.2 Monitoring Point Casing and Screen	2-7
2.1.2.3 Sand Filter Pack and Annular Sealant.....	2-9
2.1.2.4 Protective Cover.....	2-9
2.1.3 Monitoring Point Development.....	2-9
2.2 Groundwater Sampling	2-10
2.2.1 Preparation for Sampling	2-10
2.2.2 Well/Point Purging and Sample Collection	2-13
2.2.3 Onsite Chemical Parameter Measurement	2-13
2.2.4 Sample Handling.....	2-15
2.3 Aquifer Testing	2-15
2.4 Surveying	2-16
SECTION 3 - PHYSICAL CHARACTERISTICS OF THE STUDY AREA.....	3-1
3.1 Surface Features	3-1
3.1.1 Topography.....	3-1
3.1.2 Surface Water Hydrology	3-1
3.2 Regional Geology and Hydrogeology	3-3
3.3 Site Geology and Hydrogeology	3-5
3.3.1 Lithology and Stratigraphic Relationships	3-5
3.3.2 Groundwater Hydraulics.....	3-9
3.3.2.1 Flow Direction and Gradient	3-9

TABLE OF CONTENTS (Continued)

	Page
3.3.2.2 Hydraulic Conductivity.....	3-12
3.3.2.3 Effective Porosity	4-13
3.3.2.4 Advective Groundwater Velocity	4-13
3.3.2.5 Preferential Flow Paths.....	4-13
3.3.3 Groundwater Use	4-14
3.4 Climate.....	4-14
SECTION 4 - CONTAMINANT DISTRIBUTION AND EVIDENCE FOR	
BIODEGRADATION.....	4-1
4.1 Contaminant Sources and Soil Chemistry.....	4-1
4.1.1 Contaminant Sources.....	4-1
4.1.2 Total Organic Carbon in Soil	4-2
4.2 Overview of Hydrocarbon Biodegradation.....	4-4
4.2.1 Review of Biodegradation Processes.....	4-5
4.2.2 Biodegradation of BTEX	4-7
4.2.3 Biodegradation of Chlorinated Solvents	4-8
4.2.3.1 Electron Acceptor Reactions (Reductive Dehalogenation)	4-9
4.2.3.2 Electron Donor Reactions.....	4-12
4.2.3.3 Cometabolism.....	4-13
4.2.3.4 Behavior of Chlorinated Solvent Plumes.....	4-14
4.2.4 Abiotic Degradation of Chlorinated Solvents.....	4-18
4.3 Distribution of Hydrocarbons and Daughter Products	4-19
4.3.1 Fuel Hydrocarbons	4-20
4.3.2 Chlorinated Ethenes	4-23
4.3.3 Chlorinated Ethanes	4-28
4.3.4 Chlorobenzenes	4-30
4.3.5 Other Chlorinated Compounds	4-32
4.3.6 Chloride.....	4-32
4.4 Additional Evidence of Biodegradation	4-35
4.4.1 Electron Donors, Native Electron Acceptors, and Byproducts.....	4-35
4.4.1.1 Organic Carbon in Groundwater	4-36
4.4.1.2 Inorganic Chemistry	4-38
4.4.2 Additional Geochemical Indicators.....	4-46
4.4.2.1 Oxidation/Reduction Potential.....	4-46
4.4.2.2 Alkalinity and Carbon Dioxide Evolution	4-47
4.4.2.3 Ammonia/Ammonium	4-48
4.4.2.4 pH	4-51
4.4.2.5 Temperature.....	4-51

TABLE OF CONTENTS (Continued)

	Page
4.5 Approximation of Biodegradation Rates	4-52
4.6 Discussion	4-53
 SECTION 5 - GROUNDWATER MODELING	 5-1
5.1 General Overview	5-1
5.2 Conceptual Model Design and Assumptions.....	5-3
5.3 Initial Model Setup.....	5-4
5.3.1 Groundwater Gradient	5-4
5.3.2 Dissolved Contaminant Concentrations.....	5-5
5.3.3 Degradation Rates	5-5
5.4 Model Calibration	5-10
5.5 Model Results.....	5-11
5.6 Sensitivity Analysis	5-12
 SECTION 6 - COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES	 6-1
6.1 Remedial Alternative Evaluation Criteria.....	6-1
6.1.1 Long-Term Effectiveness and Permanence	6-2
6.1.2 Implementability	6-2
6.1.3 Cost.....	6-2
6.2 Factors Influencing Alternatives Development.....	6-3
6.2.1 Program Objectives	6-3
6.2.2 Contaminant Properties	6-4
6.2.3 Site-Specific Conditions	6-8
6.2.3.1 Physical Characteristics	6-8
6.2.3.2 Geochemical Characteristics.....	6-10
6.2.3.3 Potential Receptor Exposure Pathways.....	6-11
6.2.3.4 Remediation Goals for Shallow Groundwater.....	6-12
6.2.4 Summary of Remedial Option Screening.....	6-13
6.3 Brief Description of Remedial Alternatives.....	6-14
6.3.1 Alternative 1 - RNA and Institutional Controls with Long-Term Groundwater Monitoring	6-14
6.3.2 Alternative 2 - Biosparging, RNA, and Institutional Controls with Long-Term Groundwater Monitoring	6-19
6.3.3 Alternative 3 - Groundwater Extraction and Treatment, RNA, and Institutional Controls with Long-Term Groundwater Monitoring.....	6-21

TABLE OF CONTENTS (Continued)

	Page
6.4 Evaluation of Alternatives.....	6-22
6.4.1 Alternative 1 - RNA and Institutional Controls with Long-Term Groundwater Monitoring	6-22
6.4.1.1 Effectiveness	6-22
6.4.1.2 Implementability.....	6-23
6.4.1.3 Cost	6-24
6.4.2 Alternative 2 - Biosparging, RNA, and Institutional Controls with Long-Term Groundwater Monitoring	6-25
6.4.2.1 Effectiveness	6-25
6.4.2.2 Implementability.....	6-25
6.4.2.3 Cost	6-26
6.4.3 Alternative 3 -Groundwater Extraction, RNA, and Institutional Controls with Long-Term Groundwater Monitoring	6-26
6.4.3.1 Effectiveness	6-26
6.4.3.2 Implementability.....	6-28
6.4.3.3 Cost	6-28
6.5 Recommended Remedial Approach.....	6-29
 SECTION 7 - LONG-TERM MONITORING PLAN	 7-1
7.1 Overview	7-1
7.2 Monitoring Networks	7-1
7.2.1 Long-Term Monitoring Wells	7-2
7.2.2 Sentry Wells.....	7-4
7.3 Groundwater Sampling	7-5
7.3.1 Analytical Protocol	7-6
7.3.2 Sampling Frequency.....	7-6
 SECTION 8 - CONCLUSIONS AND RECOMMENDATIONS	 8-1
 SECTION 9 - REFERENCES.....	 9-1

TABLE OF CONTENTS (Continued)

LIST OF TABLES

No.	Title	Page
2.1	Monitoring Point And Monitoring Well Completion Data	2-4
2.2	Analytical Protocols For Groundwater And Soil Samples.....	2-11
3.1	Summary of Groundwater Elevation Data November 1996.....	3-10
3.2	1996 Slug Test Results.....	3-12
4.1	Soil Analytical Data.....	4-3
4.2	Groundwater Quality Data Summary for BTEX, TMBs, and TVH.....	4-21
4.3	Groundwater Quality Data Summary for Chlorinated VOCs	4-24
4.4	Groundwater Electron Acceptors/Byproducts	4-33
4.5	Groundwater Geochemical Indicators Analytical Data.....	4-37
4.6	Concentration Histories for Compounds Detected in Groundwater in Concentrations Exceeding MCLs	4-55
5.1	First Order Rate Constant Calculation Using the Method of Buscheck and Alcantar (1995)	5-7
5.2	First Order Rate Constant Calculation Using the Method of Buscheck and Alcantar (1995)	5-8
5.3	First Order Rate Constant Calculation Using the Method of Buscheck and Alcantar (1995)	5-9
6.1	Groundwater Quality Standards	6-13
6.2	Initial Technical Implementatbility Screening of Technologies and Process Options for Groundwater Remediation	6-15
6.3	Alternative 1 - Cost Estimate	6-24
6.4	Alternative 2 - Cost Estimate	6-27
6.5	Alternative 3 - Cost Estimate	6-29
6.6	Summary of Remedial Alternatives Evaluation for Groundwater Remediation	6-30
7.1	Long-Term Monitoring Analytical Protocol	7-7
7.2	Point-of-Compliance Monitoring Analytical Protocol.....	7-9

LIST OF FIGURES

No.	Title	Page
1.1	Location of Columbus AFB.....	1-6
1.2	Site Map	1-8
2.1	Groundwater and Soil Samling Locations.....	2-3
3.1	Topographic Map.....	3-2

TABLE OF CONTENTS (Continued)

LIST OF FIGURES (Continued)

No.	Title	Page
3.2	Locations of Hydrogeologic Cross-Sections	3-6
3.3	Hydrogeologic Cross-Section A-A'	3-7
3.4	Hydrogeologic Cross-Section B-B'	3-8
3.5	Water Table Elevations November 1996.....	3-11
4.1	Anaerobic Reductive Dechlorination	4-10
4.2	Aerobic Dechlorination	4-15
4.3	Areal Extent of Dissolved Total BTEX November	4-22
4.4	cis-1,2-DCE/1,1-DCE in Groundwater Isopleth Map November 1996	4-25
4.5	Vinyl Chloride in Groundwater Isopleth Map November 1996	4-26
4.6	Chlorinated Ethanes and 1,1-DCE in Groundwater Isopleth Map November 1996.....	4-29
4.7	Chlorobenzenes in Groundwater Isopleth Map November 1996.....	4-31
4.8	Chloride in Groundwater Isopleth Map November 1996	4-34
4.9	Dissolved Oxygen in Groundwater Isopleth Map November 1996.....	4-39
4.10	Nitrate & Nitrite (as N) in Groundwater Isopleth Map November 1996	4-41
4.11	Ferrous Iron in Groundwater Isopleth Map November 1996	4-42
4.12	Sulfate in Groundwater Isopleth Map November 1996	4-44
4.13	Methane in Groundwater Isopleth Map November 1996	4-45
4.14	Dissolved Carbon Dioxide in Groundwater Isopleth Map November 1996	4-49
4.15	Dissolved Ammonia/Ammonium in Groundwater Isopleth Map November 1996.....	4-50
7.1	Proposed Long-Term Monitoring and Sentry Well Locations	7-3

ACRONYMS AND ABBREVIATIONS

$\mu\text{g/kg}$	micrograms per kilogram
$\mu\text{g/L}$	micrograms per liter
AETC	Air Education and Training Command
AFB	Air Force Base
AFCEE	United States Air Force Center for Environmental Excellence
ASCII	American Standard Code for Information Interchange
ATC	Air Training Command
$\text{atm}\cdot\text{m}^3/\text{mol}$	atmosphere-cubic meters per mole
bgs	below ground surface
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, and xylenes
$^{\circ}\text{C}$	degrees Centigrade
CaCO_3	calcium carbonate
CA	chloroethane
CAH	chlorinated aliphatic hydrocarbon
CB	chlorobenzene
DCA	dichloroethane
DCB	dichlorobenzene
DCE	dichloroethene
DCM	dichloromethane
DO	dissolved oxygen
ESE	Environmental Science and Engineering, Inc.
ft/day	feet per day
ft/ft	foot per foot
ΔG°_r	Gibbs free energy of the reaction
HDPE	high density polyethylene
ID	inside diameter
IRP	Installation Restoration Program
LF-06	Landfill 6
LTM	long-term monitoring
MCL	maximum contaminant level
MDEQ	Mississippi Department of Environmental Quality
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mm Hg	millimeters of mercury
msl	mean sea level
N	nitrogen
NAPL	nonaqueous-phase liquid
OH	hydroxyl group
Parsons ES	Parsons Engineering Science, Inc.
PA/SI	preliminary assessment/site inspection

PCA	tetrachloroethane
PCE	tetrachloroethene
PID	photoionization detector
PVC	polyvinyl chloride
QC	quality control
RAO	remedial action objective
redox	reduction/oxidation
RI	remedial investigation
RNA	remediation by natural attenuation
SAC	Strategic Air Command
SAP	Sampling and Analysis Plan
SS	stainless steel
SVE	soil vapor extraction
TCA	trichloroethane
TCB	trichlorobenzene
TCE	trichloroethene
TeCB	tetrachlorobenzene
TEMB	tetramethylbenzene
TMB	trimethylbenzene
TOC	total organic carbon
TRPH	total recoverable petroleum hydrocarbons
TS	Treatability Study
TVH	total volatile hydrocarbons
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
VC	vinyl chloride
VOC	volatile organic compound

SECTION 1

INTRODUCTION

This Treatability Study (TS) was conducted by Parsons Engineering Science, Inc. (Parsons ES) to evaluate remediation by natural attenuation (RNA) of fuel-hydrocarbon and chlorinated-solvent contaminated groundwater at Landfill 6 (LF-06) at Columbus Air Force Base (AFB), Mississippi. As used in this report, RNA refers to a management strategy that relies on natural attenuation mechanisms to remediate contaminants dissolved in groundwater and to control receptor exposure risks associated with contaminants in the subsurface. The United States Environmental Protection Agency (USEPA) defines natural attenuation as (Wilson, 1996):

The naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media. These in-situ processes include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants.

As suggested by this definition, mechanisms for natural attenuation include both destructive and non-destructive processes. Non-destructive processes may reduce contaminant toxicity, mobility, volume, or concentration; however, mass is unaffected. Of these processes, biodegradation is the most common mechanism working to transform fuel hydrocarbons and chlorinated solvents into innocuous byproducts. Contaminant destruction occurs through biodegradation when indigenous microorganisms work to bring about a reduction in the total mass of contamination in the subsurface without artificial intervention (e.g., the addition of nutrients). Patterns and rates of natural attenuation can vary markedly from site to site, and within a single

contaminant plume at a given site, depending on governing physical and chemical processes.

1.1 SCOPE AND OBJECTIVES

Parsons ES was retained by the United States Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division to conduct site characterization and groundwater modeling to evaluate the scientific defensibility of RNA with long-term monitoring (LTM) as a component of remediation for contaminated groundwater at Columbus AFB. The primary objective of this project was to determine the degree to which natural attenuation processes for fuel hydrocarbons and chlorinated solvents are occurring in groundwater at the site. Performance of the following tasks was required to fulfill the project objectives:

- Reviewing previously reported hydrogeologic, soil, and groundwater data for the site;
- Conducting supplemental site characterization activities to more thoroughly characterize the nature and extent of soil and groundwater contamination;
- Collecting geochemical data in support of RNA;
- Developing a conceptual hydrogeologic model of the shallow saturated zone, including the current distribution of contaminants;
- Evaluating site-specific data to determine whether natural processes of contaminant attenuation and destruction are occurring in groundwater for dissolved concentrations of fuel hydrocarbon and chlorinated solvent compounds at the site;
- Calibrating an analytical flow and transport model to replicate observed site conditions;

- Simulating the fate and transport of benzene, toluene, ethylbenzene, and xylenes (BTEX) and chlorinated solvents in groundwater under the influence of biodegradation, advection, dispersion, and adsorption using the calibrated flow and transport model;
- Evaluating a range of model input parameters to determine the sensitivity of the model to those parameters and to consider several contaminant fate and transport scenarios;
- Determining if natural processes are sufficient to reduce dissolved hydrocarbon and chlorinated solvent plume expansion so that water quality standards can be met at a downgradient location;
- Simulating the effects of candidate remedial technologies and comparing results to preliminary remedial action objectives (RAOs);
- Using the results of modeling to recommend the most appropriate remedial option based on specific effectiveness, implementability, and cost criteria; and
- Providing a LTM plan that includes LTM and sentry well locations and a sampling and analysis plan.

The field work conducted under this program was oriented toward collecting supplementary hydrogeological and chemical data necessary to document and model natural attenuation mechanisms currently operating at the site. During November 1996, site characterization activities included use of the Geoprobe® direct-push technology for soil sample collection and temporary monitoring point installation; aquifer testing; and sampling and analysis of groundwater from temporary groundwater monitoring points and previously installed monitoring wells. Much of the hydrogeological and groundwater chemical data necessary to evaluate RNA were

available from previous investigations conducted at this site, at other sites with similar characteristics, or in technical literature.

Site-specific chemical evidence was first used to qualitatively evaluate destructive natural attenuation mechanisms, and to deduce the types of destructive mechanisms operating to reduce chlorinated solvents and fuel hydrocarbon mass at the site. Finally the chemical evidence was used to approximate destructive attenuation rates.

Following the chemical evaluation, site-specific hydrogeologic and chemical data were used to develop an analytical fate and transport model for the site to evaluate processes of natural attenuation. The modeling effort was used to simulate the movement of dissolved contaminants in the shallow saturated zone under the influence of biodegradation, advection, dispersion, and sorption. Results of the model were used to assess the potential for completion of exposure pathways involving groundwater and to determine whether RNA with LTM is an appropriate and defensible remedial option for contaminated groundwater. The results will be used to provide technical support for the RNA with LTM remedial option during regulatory negotiations, as appropriate.

This report contains nine sections, including this introduction, and five appendices. Section 2 summarizes site characterization activities. Section 3 summarizes the physical characteristics of the study area. Section 4 describes the nature and extent of soil and groundwater contamination and the geochemistry of soil and groundwater at the site. Section 5 describes the fate and transport model and design of the conceptual model for the site, lists model assumptions and input parameters, and describes sensitivity analyses. Section 6 presents a comparative analysis of remedial alternatives and predictive model results. Section 7 presents the LTM plan for the site. Section 8 presents the conclusions of this work and provides recommendations for further work at the site. Section 9 lists the references used to develop this document. Appendix A contains Geoprobe[®] borehole logs, monitoring point installation records, and slug test results. Appendix B presents soil and groundwater analytical results. Appendix C

contains calculations and model input parameters. Appendix D contains model input and output in American Standard Code for Information Interchange (ASCII) format on a diskette. Appendix E contains calculations for remedial option design and costing.

1.2 FACILITY BACKGROUND

Columbus AFB is in northeastern Mississippi, in the northwestern portion of Lowndes County (Figure 1.1). Columbus AFB covers approximately 4,411 acres in a lightly urbanized area 10 miles north of Columbus, Mississippi. Columbus AFB was initially activated on February 9, 1942 as a pilot training facility. It was closed in 1946 and remained inactive until 1951, when it was reopened as a contract flying school operated by California Eastern Airways, Inc. On April 1, 1955, the United States Air Force (USAF) Air Training Command (ATC) transferred the Base to the Second Air Force of the Strategic Air Command (SAC). An active building program was instituted by SAC to prepare the Base for its mission as the home of a B-52 squadron and a KC-135 tanker squadron, both of which arrived in 1959. ATC regained jurisdiction of the Base on July 1, 1969. The training missions at Columbus AFB require the use and maintenance of T-1, T-37, T-38, and AT-38 training aircraft. ATC became the Air Education and Training Command (AETC) on July 1, 1993. Base Realignment and Closure (BRAC) decisions in 1991, 1993, and 1995 continue to impact the mission and structure of the Base (Spencer, 1996b).

Site LF-06, Landfill Number 6, is located near the southeastern corner of the Base, directly south of the main runway and near the main gate. The landfill was operated as a disposal area for sanitary trash, ferrous metal debris, and concrete debris from 1964 through 1974. North-south trenches 8 to 10 feet deep were used for trash disposal. Initial trenches were created on the western side of the landfill, and subsequent filling activities proceeded in an easterly direction. No trenches on the east side of the landfill were used because of a near-surface water table (2 feet below the surface) (CH2M Hill, 1989). The landfill is covered by grass, with trees and thick vegetation covering the east and south portions of the landfill.

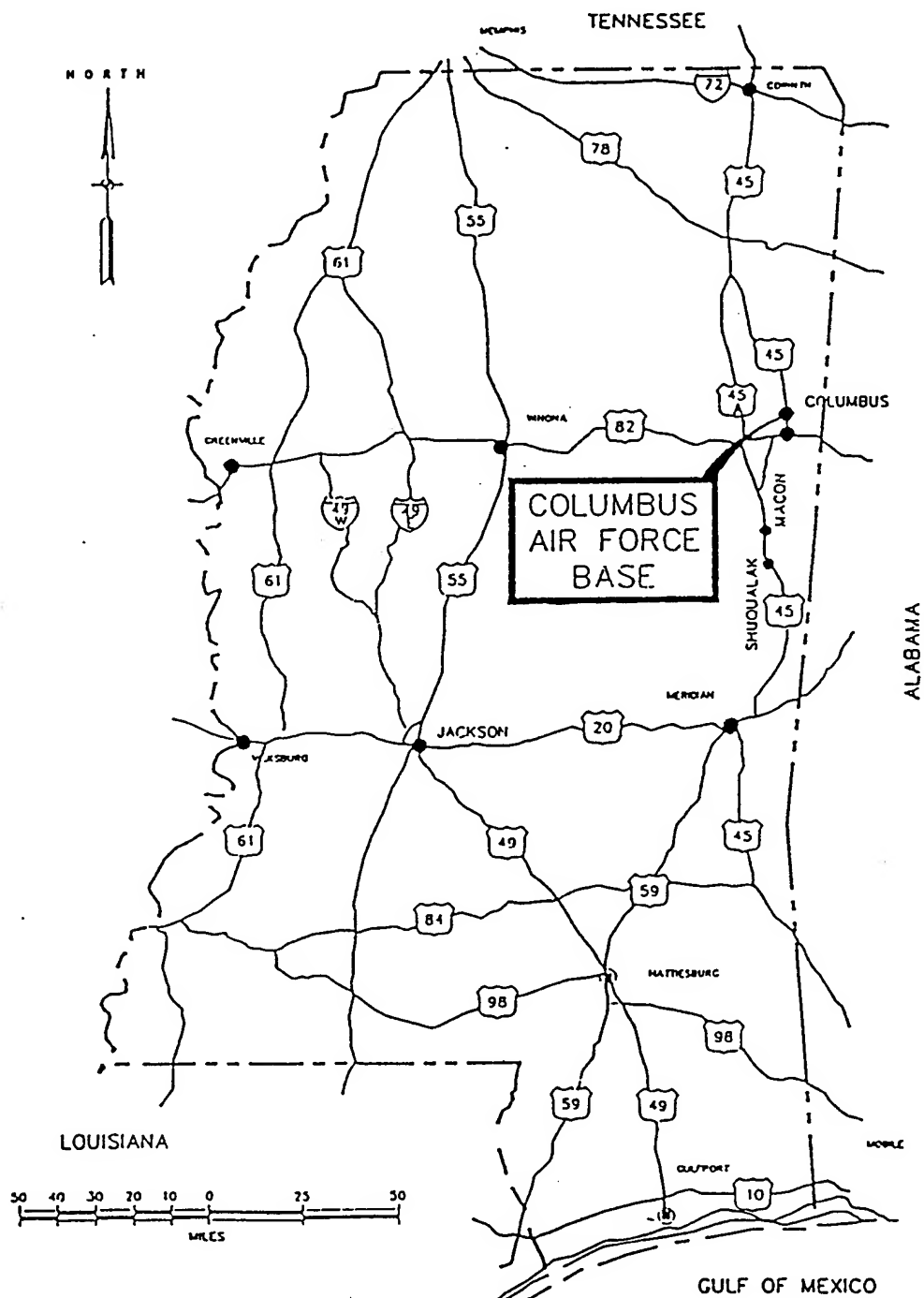


FIGURE 1.1

LOCATION OF COLUMBUS AFB

Site LF-06 RNA TS
Columbus AFB, Mississippi

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

In 1985, a preliminary assessment/site inspection (PA/SI) was conducted by Environmental Science and Engineering, Inc. (ESE) as part of the Installation Restoration Program (IRP). The PA/SI identified 15 potentially contaminated sites, including Site LF-06. In 1988 and 1989, a remedial investigation (RI) was conducted by CH2M Hill (1989) to investigate the 15 sites identified in the PA/SI. As part of the RI activities, a geophysical survey was conducted to delineate the landfill boundary (Figure 1.2). In April 1988, nine sediment samples and two surface water samples were collected along drainageways east and south of the site, and five monitoring wells were installed and sampled. The monitoring wells were sampled again in July 1988 and December 1988. In May 1989, three additional monitoring wells were installed to further evaluate the extent of vinyl chloride and mercury in groundwater in the vicinity of Site LF-06, and two downgradient monitoring wells were installed near the southern property boundary of the Base to determine if dissolved contamination had migrated beyond property boundaries (CH2M Hill, 1989). All site monitoring wells were sampled in August 1995 as part of the groundwater LTM program at Columbus AFB (Spencer, 1996a).

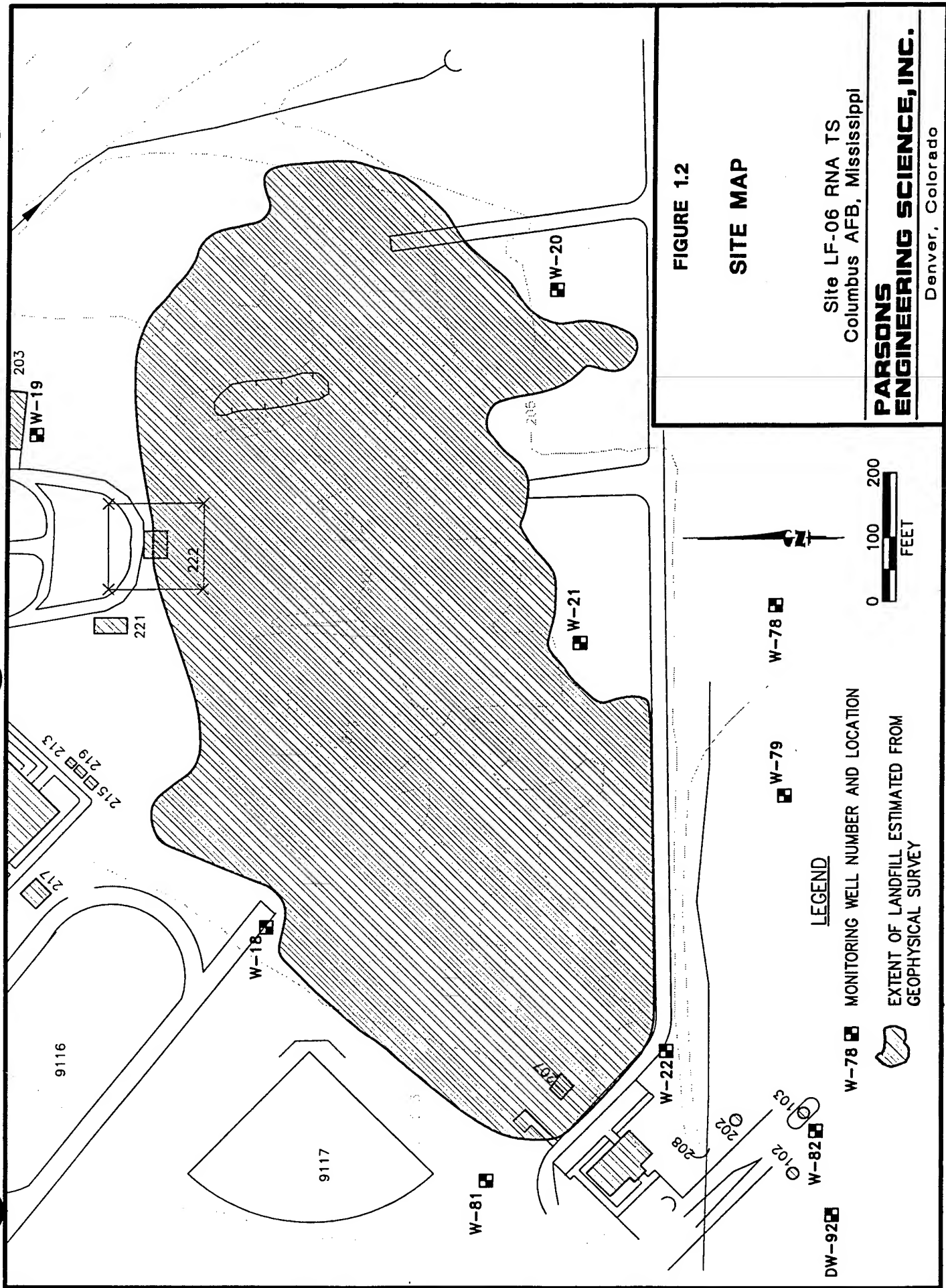


FIGURE 1.2

SITE MAP

Site LF-06 RNA TS
Columbus AFB, Mississippi

**PARSONS
ENGINEERING SCIENCE, INC.**
Denver, Colorado

SECTION 2

SITE CHARACTERIZATION ACTIVITIES

This section presents the methods used by Parsons ES personnel to collect site-specific data at Site LF-06 at Columbus AFB, Mississippi. The site characterization was performed in November 1996, and consisted of monitoring point installation, soil and groundwater sampling, and aquifer testing to evaluate near-surface geology and geochemistry, aquifer properties, and the extent of soil and groundwater contamination for the area surrounding LF-06. Temporary groundwater monitoring point installation and soil sampling were accomplished using the Geoprobe® direct-push system. Groundwater sampling was accomplished using both temporary monitoring points and previously installed monitoring wells. Hydraulic conductivity (slug) tests were conducted at several of the site monitoring wells. Previously collected data were integrated with data collected under this program to develop the conceptual site model and to aid interpretation of the physical setting (Section 3) and contaminant distribution (Section 4).

The following sections describe the procedures that were followed when collecting site-specific data. Additional details regarding investigative activities are presented in the work plan (Parsons ES, 1996).

2.1 DRILLING, SOIL SAMPLING, AND MONITORING POINT INSTALLATION

Drilling-related field work occurred between November 8 and November 17, 1996, and consisted of soil sampling and temporary groundwater monitoring point installation. Twenty-one temporary groundwater monitoring points were installed at 17 locations to assist in the characterization of the shallow groundwater flow system at Site LF-06. These points were identified as MPA(s), MPA(d), MPB, MPC(s), MPC(d), MPD(s), MPD(d),

MPF(s), MPF(d), MPG, MPH, MPI, MPJ, MPK, MPL, MPM, MPN, MPO, MPP, MPQ, and MPR. The new points were installed in the locations shown on Figure 2.1. Table 2.1 presents monitoring well completion details. Four sets of clustered points were installed, with one well (designated by the suffix "s") screened near the water table surface, and with the deeper well (designated by the suffix "d") screened at the base of the unconsolidated shallow aquifer immediately above the semi-impervious clay layer. The well locations were selected to provide the hydrogeologic data necessary for successful implementation of fate and transport modeling and to support the RNA demonstration. These activities were performed according to the procedures described in the work plan (Parsons ES, 1996) and in the following sections.

2.1.1 Geoprobe® Operation

The Geoprobe® system is a hydraulically powered percussion/probing machine used to advance sampling tools through unconsolidated soils. This system provides for the rapid collection of soil, soil gas, and groundwater samples at shallow depths while minimizing the generation of investigation-derived waste materials. For convenience, throughout this report, operation of the Geoprobe® is referred to as "drilling".

2.1.1.1 Pre-Drilling Activities

All subsurface utility lines or other man-made subsurface features were located, and proposed drilling locations were cleared and approved by the Base prior to any drilling activities. Water used in equipment cleaning or grouting was obtained from a potable water supply designated by the Base.

2.1.1.2 Equipment Decontamination Procedures

Prior to arriving at the site, and between each drilling location, all probe rods, tips, sleeves, pushrods, samplers, tools, and other downhole equipment were decontaminated using an Alconox® detergent and potable water solution followed by a potable water wash. Fittings, tips, and samplers also underwent an additional rinse with isopropyl alcohol

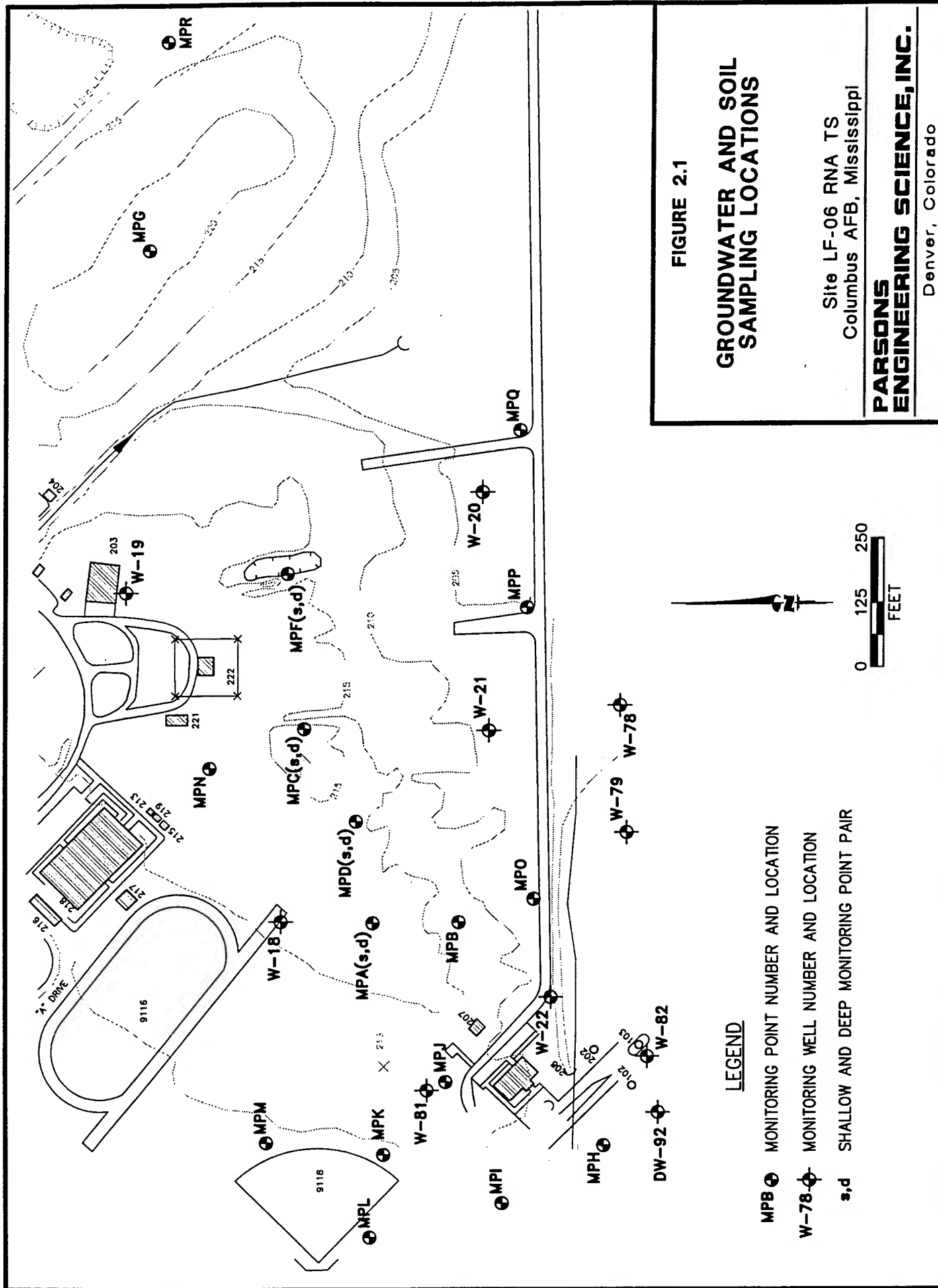


TABLE 2.1
MONITORING POINT AND MONITORING WELL COMPLETION DATA
LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Well Identification	Installation Date	Well Diameter (inches)	Total Depth Measured (Feet toc)	Screened Interval (feet bgs) ^{u/}	Survey Northing (State Plane) ^{v/}	Survey Easting (State Plane)	Elevation of Reference Point for Measurements (feet msl) ^{e/}	Elevation Datum
Monitoring Points								
MPA(s)	11/12/96	0.5		10.5-15.5	1439839.5921	621166.0172	216.7	Top of PVC Casing
MPA(d)	11/17/96	0.375		30.7-31.2	1439839.5921	621166.0172	217.7	Top of Tubing
MPB	11/9/96	0.5		7-12	1439643.0514	621168.3734	211.9	Top of PVC Casing
MPB(s)	11/16/96	0.5		20-23	1440002.2419	621620.4489	218.7	Top of PVC Casing
MPC(d)	11/16/96	0.375		31.1-31.6	1440002.2419	621620.4489	219.9	Top of Tubing
MPD(s)	11/16/96	0.5		15-18	1439880.2070	621404.3915	216.5	Top of PVC Casing
MPD(d)	11/16/96	0.375		31.1-31.6	1439880.2070	621404.3915	217.6	Top of Tubing
MPF(s)	11/15/96	0.5		11-14	1440040.7906	621987.1107	215.0	Top of PVC Casing
MPF(d)	11/15/96	0.375		30.5-31	1440040.7906	621987.1107	216.0	Top of Tubing
MPG	11/13/96	0.5		15-18	1440365.4145	622741.1228	219.3	Top of PVC Casing
MPH	11/13/96	0.5		9-14	1439306.1636	620642.9713	208.6	Top of PVC Casing
MPI	11/15/96	0.5		23-26	1439541.5590	620508.3941	206.7	Top of PVC Casing
MPJ	11/12/96	0.375		18.5-19	1439669.5326	620792.4084	213.4	Top of PVC Casing
MPK	11/14/96	0.5		15-18	1439815.8194	620620.2490	209.3	Top of PVC Casing
MPL	11/14/96	0.5		12-17	1439848.2203	620429.6530	206.6	Top of PVC Casing
MPM	11/13/97	0.5		15-18	1440089.8564	620650.4350	208.5	Top of PVC Casing
MPN	11/16/96	0.5		24-27	1440221.4005	621528.6319	219.1	Top of PVC Casing
MPO	11/13/96	0.5		9-14	1439452.8637	621222.0761	203.6	Top of PVC Casing
MPP	11/12/96	0.5		8-14	1439472.5487	621894.2265	204.9	Top of PVC Casing
MPQ	11/12/96	0.5		8-14	1439501.9037	622302.9421	204.3	Top of PVC Casing
MPR	11/14/96	0.5		13-16	1440344.4043	623216.8753	212.7	Top of PVC Casing
Monitoring Wells								
W18	2/29/88	2.0		21-31	1440056.0402	621169.7223	215.6	Top of PVC Casing
W19	3/1/88	2.0		20.5-30.5	1440413.5 ^{u/}	621948.89 ^{u/}	219.0 ^{d/}	Top of PVC Casing
W20	3/1/88	2.0		13-23	1439588.3460	622175.2869	205.6	Top of PVC Casing
W21	2/28/88	2.0		18-28	1439564.86 ^{u/}	621616.88 ^{u/}	207.2 ^{d/}	Top of PVC Casing
W22	3/1/88	2.0		11.5-21.5	1439427.1258	620992.4735	208.7	Top of PVC Casing
W78	5/25/89	2.0		10-20	1439168.24 ^{u/}	621658.51 ^{u/}	206.8 ^{d/}	Top of PVC Casing
W79	5/26/89	2.0		10-20	1439177.54 ^{u/}	621310.63 ^{u/}	208.0 ^{d/}	Top of PVC Casing
W81	11/4/94	2.0		17-27	1439155.87 ^{u/}	620830.78 ^{u/}	212.2 ^{e/}	Top of PVC Casing
W82	11/5/94	2.0		15-25	1439807.23 ^{u/}	620810.93 ^{u/}	207.2 ^{e/}	Top of PVC Casing

^{u/} Feet bgs = feet below ground surface.

^{v/} State Plane = State of Mississippi Plane Coordinate System.

^{e/} Feet msl = feet above mean sea level.

^{d/} Reference point elevation determined by adding 0.3 ft to survey data reported by CH2M Hill in 1989.

^{e/} Reference point elevation obtained from well installation records produced by CH2M Hill in November, 1994.

^{u/} Easting and northing survey coordinates obtained from BCM/Smith survey, 1996

followed by a final rinse with deionized water. Precautions were taken to minimize impact to the areas surrounding decontamination operations. All decontamination activities were conducted in a manner so that the excess water was controlled and not allowed to flow into any open borehole.

All decontamination fluids were collected and contained in 55-gallon drums. The contents of the drums were inspected prior to release to the Base sanitary sewer. If the water had exhibited a sheen or odor of any kind, the water would have been transported to a temporary holding facility designated by the Base. None of the water exhibited signs of contamination, and therefore, Base Civil Engineering was notified and the water was released to the sanitary sewer.

2.1.1.3 Drilling and Soil Sampling

Drilling was accomplished using the Geoprobe[®] direct-push technology. The boreholes were sampled continuously to the total depth of the borehole. Where two points were installed adjacent to each other (i.e., nested), only the deeper point was logged and sampled. The Geoprobe[®]-collected soil samples were obtained using 4 foot by 1.5 inch inside diameter (ID) and 2 foot by 1-1/16-inch ID sampling devices. The large sampler was used for the initial 10 feet of soil. The smaller sampler was then used for the remainder of the borehole in an attempt to minimize the smearing of surface contamination into deeper portions of the borehole. A probe-drive sampler attached to the leading end of the probe rods serves as both the driving point and the sample collection device. To collect a soil sample, the sampler was pushed or driven to the desired sampling depth, the drive point was retracted to open the sampling barrel, and the sampler was subsequently pushed into the undisturbed soils. The soil cores were retained within a clear acetate liner inside the sampling barrel. The probe rods were then retracted, bringing the sampling device to the surface. The soil sample was then extruded from the liners for visual lithologic logging, photoionization detector (PID) headspace screening, and collection for chemical testing at an analytical laboratory.

The Parsons ES field geologist observed drilling and monitoring point installation activities and maintained a detailed descriptive log of recovered subsurface materials. Final geologic borehole logs are presented in Appendix A. These logs contain:

- Sampled interval (top and bottom depth);
- Presence or absence of contamination based on odor, staining, and/or PID readings;
- Soil description, including color, major textural constituents, minor constituents, relative moisture content, plasticity of fines, cohesiveness, grain size, structure or stratification, and any other significant observations; and
- Lithologic contacts, with the depth to contacts and/or significant textural changes recorded to the nearest 0.1 foot.

Bags containing soil samples collected for the headspace screening procedure were quickly sealed and stored for 15 minutes or longer at the ambient temperature. Semiquantitative measurements were made by puncturing the bag seal with the PID probe and reading the concentration of the headspace gases. The PID relates the concentration of total volatile organic compounds (VOCs) in the sample to an isobutylene calibration standard. The PID also was used to monitor for VOCs in the worker breathing zone.

Soil samples were collected from boreholes MPF, MPJ, and MPL. At MPF and MPJ, samples submitted for laboratory analysis were from the intervals giving the highest PID headspace readings. Where no elevated PID headspace readings were encountered (MPL), a sample was collected from immediately above the water table. Analytical sample containers and appropriate container lids were provided by Envirotech, Inc. Personnel from Parsons ES performed the soil sampling.

The sample containers were filled completely to minimize headspace. The containers were sealed with Teflon[®] tape and lids were placed over the tape and tightly closed. A

sample label was attached to the container side, and the following information was legibly and indelibly written on the label:

- Sample identification;
- Requested analysis;
- Sample depth;
- Sampling date; and,
- Sample collector's initials.

After the sample containers were sealed and labeled, they were placed in a cooler with ice and held for transport to the laboratory.

2.1.2 Temporary Monitoring Point Installation

Temporary groundwater monitoring points were installed in 21 boreholes at 17 locations under this program (Figure 2.1). Detailed monitoring point installation procedures are described in the following paragraphs.

2.1.2.1 Monitoring Point Materials Decontamination

Monitoring point completion materials were inspected by the field geologist and determined to be clean and acceptable prior to use. All monitoring point completion materials were factory sealed in plastic wrap. Pre-packaged casing, sand, and bentonite were used in well construction, and were inspected for possible external contamination before use. Materials that could not be cleaned to the satisfaction of the field geologist were not used.

2.1.2.2 Monitoring Point Casing and Screen

Two designs were used to construct monitoring points. The majority of the shallow monitoring points were constructed of Schedule 40 polyvinyl chloride (PVC) riser pipe

connected to factory-slotted PVC screens having an ID of 0.5 inch. The PVC points were placed wherever formation soils did not collapse into the borehole after the Geoprobe® rods were extracted. In the event that collapsing soils prevented the placement of the PVC screen after the extraction of the soil probe the monitoring points were constructed using Teflon®-lined, high-density polyethylene (HDPE) tubing threaded through the center of the drive rods. The tubing was attached to a double-woven wire screen, which in turn was threaded into a dedicated stainless steel (SS) drive point/implant anchor that remained in place after the drive rods were removed. All PVC casing and screen sections on the shallow monitoring points were flush threaded, and glued joints were not used. The riser pipe at each PVC monitoring point was fitted with a PVC top cap, and an aluminum drive point was inserted into the bottoms of the PVC screens.

The majority of the deep monitoring points were constructed using the SS screens and Teflon®-lined HDPE tubing described above. The riser tubing for deep monitoring points extended to the surface, and the bottom of the SS mesh screen was threaded to the dedicated SS drive point/implant anchor that remained in place after the drive rods were removed.

Monitoring point screens constructed of PVC were 3 to 6 feet long and factory slotted with 0.010-inch openings. Monitoring point screens constructed of SS were 0.5 foot in length with pore openings of 0.037 inch. Shallow points were screened near the water table. Well screen positions were selected by the field hydrogeologist after consideration was given to the geology and hydraulic characteristics of the stratum in which the wells were screened.

Monitoring point construction details were noted on a monitoring point installation record and are summarized in Table 2.1. This information became part of the permanent field record for the site. Monitoring point installation records for LF-06 are presented in Appendix A.

2.1.2.3 Sand Filter Pack and Annular Sealant

Placement of a filter pack around the monitoring point casing screens was not possible as a result of the collapse of the sand borehole walls. Therefore, the temporary monitoring points were naturally sand-packed with the formation materials. Due to the sandy nature of the formation materials, well development and purging activities were accomplished without difficulty. A filter pack seal of sodium bentonite chips or grout was placed in the portion of the hole which remained open following collapse of the sandy borehole walls. This was typically the top 2 to 3 feet of the borehole.

2.1.2.4 Protective Cover

For all temporary monitoring points, protective 8-inch-diameter flush-mount casings were set into a 2-foot-square concrete pad to a depth of 0.5 to 1.0 foot bgs. The casings were cemented in place with the bottom anchored in a 6-inch thick gravel pad in order to facilitate drainage of excess storm water penetrating the protective casing. The tops of the covers were placed approximately at ground surface. Well identifications were permanently inscribed on the well casing and protective cover.

2.1.3 Monitoring Point Development

Prior to sampling, temporary monitoring points were developed. Typically, development removes sediment from inside the well casing and flushes fines, cuttings, and drilling fluids from the sand pack and the portion of the formation adjacent to the well screen. Use of the Geoprobe[®] system to place monitoring points eliminates cuttings and drilling fluids. As a result, development of monitoring points is primarily intended to minimize the amount of fine sediment that might accumulate in the casing.

Monitoring point development was accomplished using a peristaltic pump with dedicated HDPE and silicon tubing. For monitoring points constructed from 0.5 inch PVC, HDPE tubing was inserted into the well. A length of silicon tubing was attached to the end of the HDPE tubing and directed through the peristaltic pump head. For monitoring points

constructed from Teflon[®] lined tubing, HDPE tubing was not required. Instead, the silicon tubing was attached to the Teflon[®]-lined tubing comprising the monitoring point casing, and directed through the peristaltic pump head. Development was continued until a minimum of 10 casing volumes of water were removed from the point and the groundwater pH, temperature, conductivity, and dissolved oxygen concentrations had stabilized.

2.2 GROUNDWATER SAMPLING

This section describes the procedures used for collecting groundwater samples. In order to maintain a high degree of quality control (QC) during this sampling event, the procedures described in the site work plan (Parsons ES, 1996) and summarized in this section were followed.

Groundwater sampling occurred between November 13 and 19, 1996, and consisted of collecting groundwater samples from 20 newly installed temporary monitoring points and 9 existing monitoring wells (Figure 2.1). A groundwater sample could not be obtained from the newly installed monitoring point MPD(s), because it was purged dry and never recovered. Groundwater sampling forms were used to document the specific details of the sampling event for each location. Groundwater samples were analyzed for the parameters listed in Table 2.2. Groundwater samples were analyzed by Parsons ES personnel in the field for alkalinity, ammonia, dissolved oxygen (DO), total and ferrous iron, conductivity, free carbon dioxide, pH, reduction/oxidation (redox) potential, salinity, soluble manganese, sulfide, sulfate, nitrite, nitrate, chloride, and temperature. Laboratory analyses for alkalinity, chloride, methane, nitrate and nitrite, sulfate, purgeable aromatic hydrocarbons, total hydrocarbons, total organic carbon, and VOCs were performed by Evergreen Analytical, Inc.

2.2.1 Preparation for Sampling

All equipment used for sampling was assembled and properly cleaned and calibrated (if required) prior to arriving in the field. In addition, all record-keeping materials were

TABLE 2.2
ANALYTICAL PROTOCOLS FOR GROUNDWATER AND SOIL SAMPLES
LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

MATRIX Analyte	METHOD	FIELD (F) OR FIXED- BASE (L) ANALYTICAL LABORATORY
WATER		
Chloride	Colorimetric, Hach Method 1440-01 (or similar)	F
Total Iron	Colorimetric, Hach Method 8008 (or similar)	F
Ferrous Iron (Fe+2)	Colorimetric, Hach Method 8146 (or similar)	F
Ferric Iron (Fe+3)	Difference between total and ferrous iron	F
Manganese	Direct-reading meter	F
Salinity	Direct-reading meter	F
Sulfide	Colorimetric, Hach Method 8131 (or similar)	F
Sulfate	Colorimetric, Hach Method 8051 (or similar)	F
Nitrate	Titrimetric, Hach Method 8039 (or similar)	F
Nitrite	Titrimetric, Hach Method 8507 (or similar)	F
Redox Potential	A2580B, direct-reading meter	F
Oxygen	Direct-reading meter	F
pH	E150.1/SW9040, direct-reading meter	F
Conductivity	E120.1/SW9050, direct-reading meter	F
Temperature	E170.1	F
Alkalinity (Carbonate [CO3-2] and Bicarbonate [HCO3-1])	Titrimetric, Hach Method 8221 (or similar)	F
Carbon Dioxide	CHEMetrics Method 4500	F
Nitrate	E300 or SW9056	L
Nitrite	E300 or SW9056	L
Chloride	E300 or SW9056	L
Sulfate	E300 or SW9056	L
Alkalinity	E150.1	L
Methane	EAL-SOP-GC404	L
Total Organic Carbon	SW9060	L
Aromatic Hydrocarbons (Including Trimethylbenzenes and Tetramethylbenzene)	SW8020A	L
Total Hydrocarbons	SW8015	L
Volatile Organic Compounds	SW8240B	L
SOIL		
Total Organic Carbon	SW9060	L
Moisture	ASTM D-2216	L
Aromatic Hydrocarbons	SW8020	L
Total Hydrocarbons	SW8015	L
Volatile Organic Compounds	SW8240B	L

gathered prior to leaving the office. Special care was taken to prevent contamination of the groundwater and extracted samples through cross contamination from improperly cleaned equipment; therefore, water level indicators and sampling equipment were thoroughly cleaned before and after field use and between uses at different sampling locations. In addition, a clean pair of new, disposable gloves was worn each time a different well/point was sampled.

All portions of sampling and test equipment that contacted the sample were thoroughly cleaned before use. This equipment included the water level probe and cable, equipment for measuring onsite groundwater chemical parameters, and other equipment that contacted the samples. All peristaltic pump tubing was dedicated to each sampling location. The following cleaning protocol was used:

- Cleaned with potable water and phosphate-free laboratory detergent;
- Rinsed with potable water;
- Rinsed with isopropyl alcohol;
- Rinsed with distilled or deionized water;
- Air dried prior to use.

Any deviations from these procedures were documented in the field scientist's field notebook and on the groundwater sampling form. Decontamination fluids were contained as described in Section 2.1.1.2.

As required, field analytical equipment was calibrated according to the manufacturers' specifications prior to field use. This requirement applied specifically to onsite chemical measurements of DO, conductivity, and pH.

Prior to removing any water from the existing monitoring wells, the static water level was measured. An electrical water level probe was used to measure the depth to

groundwater below the well datum to the nearest 0.01 foot. After measurement of the static water level, the water level probe was lowered to the bottom of the well for measurement of total well depth (recorded to the nearest 0.01 foot). Based on these measurements, the volume of water to be purged from the monitoring wells was calculated. For the temporary monitoring points, the volume of water to be purged was estimated from the total depth of the monitoring point as recorded in the field notes.

2.2.2 Well/Point Purging and Sample Collection

A peristaltic pump was used for well evacuation. For monitoring wells, both dedicated HDPE and silicon tubing were used. For monitoring points, the same dedicated tubing arrangement described for development (Section 2.1.3) was used. Purging consisted of removing at least three times the calculated casing volume prior to sample collection. Once three casing volumes were removed from the well, purging continued until the DO, temperature, and conductivity readings had stabilized. Purge waters generated during the site characterization event were placed in 5-gallon buckets and transported to the on-site 1,200-gallon waste water tank.

The same peristaltic pump and dedicated tubing arrangement was used to extract groundwater samples from each well or Geoprobe[®] point. The groundwater sample was transferred directly into the appropriate sample container. The water was carefully poured down the inner walls of the sample bottle to minimize aeration of the sample. Sample bottles for BTEX, total fuel carbon, and VOC analyses were filled so that there was no headspace or air bubbles within the container. Table 2.2 lists the analyses performed on collected groundwater samples.

2.2.3 Onsite Chemical Parameter Measurement

Measurement of DO, pH, specific conductance, redox potential, and temperature was performed at the sampling location at the time of sample collection. All other field

parameters were measured onsite by Parsons ES personnel at their temporary laboratory immediately following sample collection.

DO measurements were taken using a YSI-55 DO meter in a flow-through cell at the outlet of the peristaltic pump. DO concentrations were recorded after the readings stabilized, and in all cases represent the lowest DO concentration observed.

Because the specific conductance, pH, redox potential, and temperature of groundwater can change significantly within a short time following sample acquisition, parameters were measured in the same flow-through cell used for DO measurements. Conductivity and temperature were measured using an Extech[®] meter. Redox potential and pH were measured using an Orion[®] 250A meter.

An onsite laboratory staffed by Parsons ES personnel was used to analyze for several indicator parameters in groundwater samples collected from pre-existing monitoring wells and newly installed monitoring points (Table 2.1). A Hach[®] DR/700 colorimeter was used to measure ferrous iron (Fe^{+2}), total iron (Fe), manganese (Mn^{+2}), and sulfide (S^{2-}). Titrations using Hach[®] reagents were conducted to measure alkalinity [as milligrams per liter (mg/L) calcium carbonate (CaCO_3)] and chloride (Cl^-); and CHEMtrac[®] color tests were used to measure ammonia (NH_3) and carbon dioxide (CO_2). These analyses were completed for each groundwater sample after all sample containers had been filled. The sample to be analyzed was poured into a clean glass container, capped, and transported to the Parsons ES on-Base laboratory for analysis. Special care was taken to avoid aerating the sample in the sample container, which could influence the concentration of reduced species. The field holding time for each sample did not exceed 0.5 hour. Care was taken to minimize sample temperature changes and exposure to sunlight. Concentrations of these indicator parameters were not measured in soil samples.

2.2.4 Sample Handling

Evergreen Analytical, Inc. provided appropriate pre-preserved sample containers. Samples were delivered to the Parsons ES temporary laboratory within minutes of sample collection. Samples for those analyses not performed by the temporary laboratory were appropriately packaged and shipped with ice to Evergreen Analytical, Inc. in Wheat Ridge, Colorado for analysis. The associated chain-of-custody documentation for the fixed-base laboratory was the responsibility of the Parsons ES field personnel.

The sample containers were filled as described in Sections 2.2.3, and the container lids were tightly closed. The sample label was firmly attached to the container side, and the following information was legibly and indelibly written on the label:

- Facility name;
- Sample identification;
- Requested analysis;
- Sample type (groundwater);
- Sampling date;
- Sampling time;
- Preservatives added; and
- Sample collector's initials.

2.3 AQUIFER TESTING

Slug tests were performed in November 1996 in wells W18, W19, W22, W79, W81, and W82 (Figure 2.1) to provide estimates for the hydraulic conductivity of the shallow saturated zone in the vicinity of LF-06. Slug tests are single-well hydraulic tests used to estimate the hydraulic conductivity of an aquifer in the immediate vicinity of the tested

well. Slug testing can be performed using either a rising head or a falling head test. Both rising head and falling head tests were performed at this site. Detailed slug testing procedures are presented in the *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater* (Wiedemeier *et al.*, 1995).

Data obtained during slug testing were analyzed using the computer program AQTESOLV® (Geraghty & Miller, Inc., 1994) and the methods of Bouwer and Rice (1976) and Bouwer (1989) for unconfined conditions. The results of slug testing are presented in Section 3.3 and Appendix A.

2.4 SURVEYING

After completion of field work in November 1996, the locations and elevations of all new monitoring wells were surveyed by CH2M Hill, a company licensed to perform land surveying. The horizontal locations and elevations of the measurement datum (top of well casing or top of outer casing) were measured relative to existing control points referenced to the Mississippi State Plane coordinate system. Horizontal locations were surveyed to the nearest 0.5 foot. Measurement datum and ground surface elevations were surveyed to the nearest 0.1 foot and referenced to mean sea level (msl) elevation. Survey data are presented in Table 2.1 and Appendix A. The locations of Geoprobe® grab samples were estimated by measuring the distance between adjacent monitoring wells and surface references.

SECTION 3

PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section describes the physical characteristics of Site LF-06 as determined from data collected by Parsons ES in November 1996, in conjunction with data documented in previous reports on LF-06 and Columbus AFB (CH2M Hill, 1989 and 1995; Spencer, 1996a and 1996b). Investigative techniques used by Parsons ES to determine the physical characteristics of the site are discussed in Section 2.

3.1 SURFACE FEATURES

3.1.1 Topography

Columbus AFB is located in northeastern Mississippi and lies in the Tombigbee and Tennessee River Hills physiographic district of the Gulf Coastal Plain (CH2M Hill, 1989). This area is characterized by a low, relatively flat terrain. Land surface elevations in the vicinity of Columbus AFB range from 180 to 220 feet above msl. A topographic map of Columbus AFB is presented as Figure 3.1.

3.1.2 Surface Water Hydrology

Columbus AFB is bounded to the west and north by the Tombigbee River and the Buttahatchie River, respectively. Surface water runoff from the Base primarily drains into the Tombigbee River, with exception of the northeastern portion of the Base, which drains into the Buttahatchie River. The northwestern corner of the Base lies within the 100-year floodplain of both rivers and occasionally floods (CH2M Hill, 1995).

3.2 REGIONAL GEOLOGY AND HYDROGEOLOGY

The shallow subsurface geology in northeastern Mississippi consists of Cretaceous Gulf Coastal Plain sediments overlain by Quaternary alluvial sediments. The Cretaceous coastal plain sediments unconformably overlie an irregular surface of Paleozoic basement rocks (CH2M Hill, 1989).

Unconsolidated sediments comprise the upper 40 feet of subsurface geology at the Base. These sediments are alluvial and lower terrace deposits composed of sand and gravel overlying clay and sandy clay. Upper units of the Cretaceous Coastal Plain sediments consist of sand, silt, gravel, clay, and calcareous marine strata. Lower units of the Cretaceous Series comprise a southward-thickening wedge of sand, clay, shale, gravel, and calcareous strata of marine origin (CH2M Hill, 1989). The upper units of the Coastal Plain sediments that crop out in the vicinity of Columbus AFB lie on the eastern flank of the Mississippian Embayment, a southward-plunging structural syncline. The embayment is essentially a large trough that subsided as Cretaceous sediments were deposited in a shallow inland sea. Stratigraphic units in the vicinity of the Base slope toward the axis of the embayment syncline, though the southwest dip of strata is less than 20 feet per mile (CH2M Hill, 1989). This structural control has resulted in north-south trending outcrop belts in areas surrounding the Base. Paleozoic basement rocks crop out only in the northeast corner of the state as Devonian and Mississippian sedimentary units.

Sandy Cretaceous sediments are the most important source of groundwater in Lowndes County. Recharge to these aquifers occurs mainly by downward infiltration of rainwater in outcrop areas (CH2M Hill, 1989). Two major hydrogeologic units are present in Lowndes County: a surficial, unconfined alluvial aquifer and the deeper, confined to semi-confined Eutaw Aquifer.

The surficial aquifer is part of the Upper Eutaw Formation, and includes the Tombigbee sand member when present. The surficial aquifer averages less than 40 feet in thickness and consists of alluvial sand, silty clay, and gravel deposits. Previous studies show the

regional hydraulic conductivity of the surficial aquifer to vary between 3.8 and 570 feet per day (ft/day) (CH2M Hill, 1989).

The semi-confining layer that separates the upper, surficial aquifer and the deeper, confined to semi-confined Eutaw Aquifer is estimated to be approximately 5 to 90 feet thick across the Base (CH2M Hill, 1995). This layer primarily consists of low permeability silt and clay interlayered with sand and has a hydraulic conductivity which ranges from 1.9×10^{-2} ft/day to 1.7×10^{-4} ft/day (CH2M Hill, 1989). Eutaw sediments of the confining layer have been identified as greenish-gray, finely laminated clay in the vicinity of the Base (Spencer, 1996a).

The confined to semi-confined Eutaw Aquifer consists of both Eutaw Formation and Tuscaloosa Group sediments. The confined Eutaw Aquifer is about 150 feet thick in the vicinity of the Base and receives most of its recharge north of the Base at the formation outcrop (CH2M Hill, 1989). The regional groundwater flow direction within the Eutaw Aquifer in the vicinity of the Base is toward the west-southwest, coinciding with the regional dip of the Formation. The Eutaw Aquifer consists of tan to brown sand (called Tuscaloosa sand) with coarse gravel and lenses of clay (CH2M Hill, 1989) and is generally identified by the presence of glauconitic sediments (Spencer, 1996a). Previous studies show the hydraulic conductivity of the Eutaw Aquifer within the Base to vary between 2 ft/day and 30 ft/day, and to average 7 ft/day (Spencer, 1996a). Beneath the Eutaw Formation is the Tuscaloosa Group, which consists of coarse sand and gravel deposits and is also considered part of the Eutaw Aquifer. Columbus AFB operates three potable water supply wells completed in the Tuscaloosa Group, at depths of approximately 400 feet bgs (CH2M Hill, 1995).

Shallow groundwater in the vicinity of the Base is typically present within the surficial aquifer at approximately 15 feet bgs. However, it is reported that groundwater elevations in the surficial aquifer may vary seasonally by as much as 10 feet, depending on rainfall patterns (CH2M Hill, 1989). Aquifer recharge occurs by downward infiltration of

rainwater through the relatively permeable alluvial deposits. Shallow groundwater within the northern section of the Base generally flows to the northwest toward the Buttahatchie River, while groundwater within the southern half of the Base, generally flows to the west-southwest toward the Tombigbee River (CH2M Hill, 1995; Spencer, 1996b).

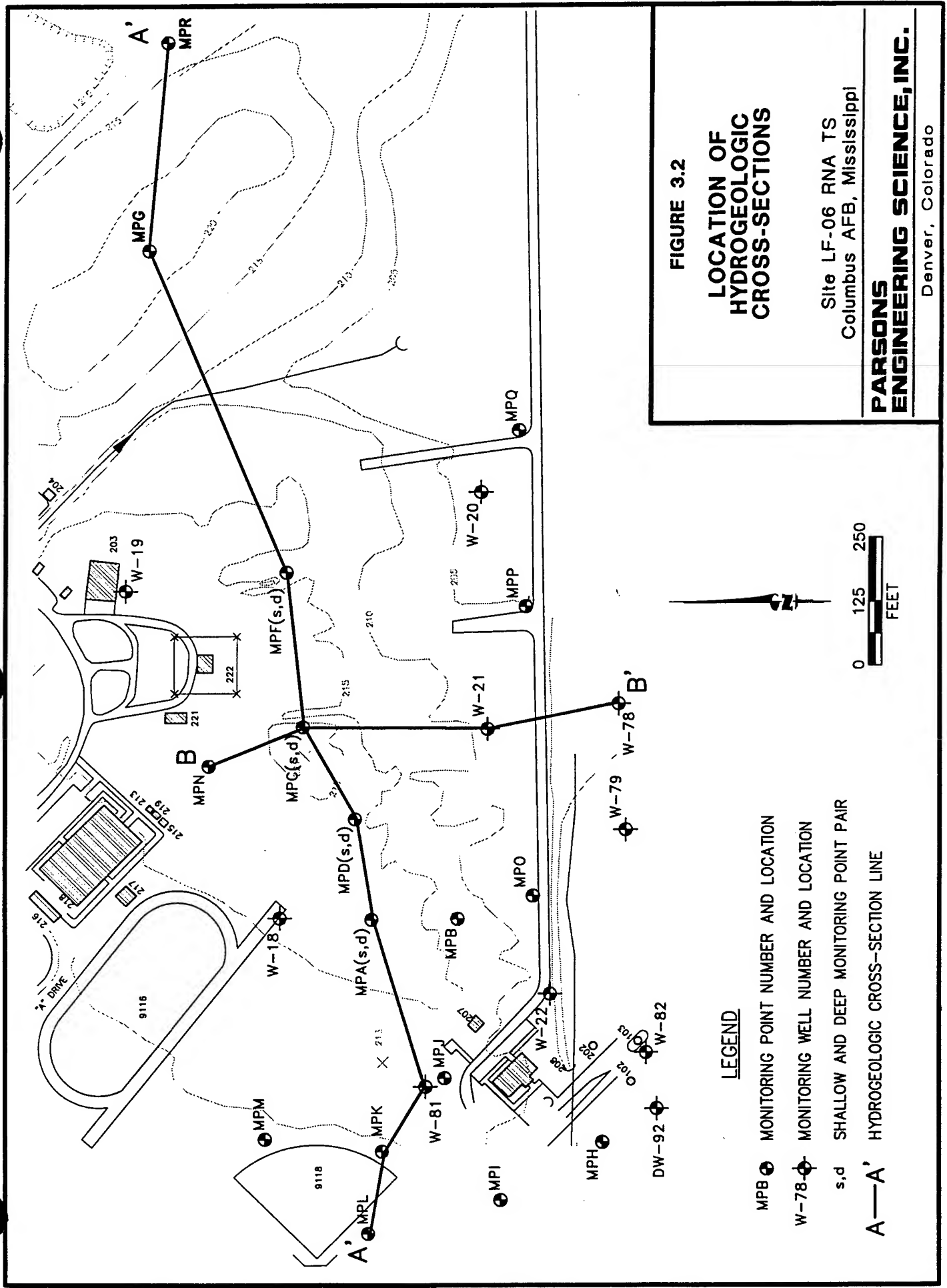
3.3 SITE GEOLOGY AND HYDROGEOLOGY

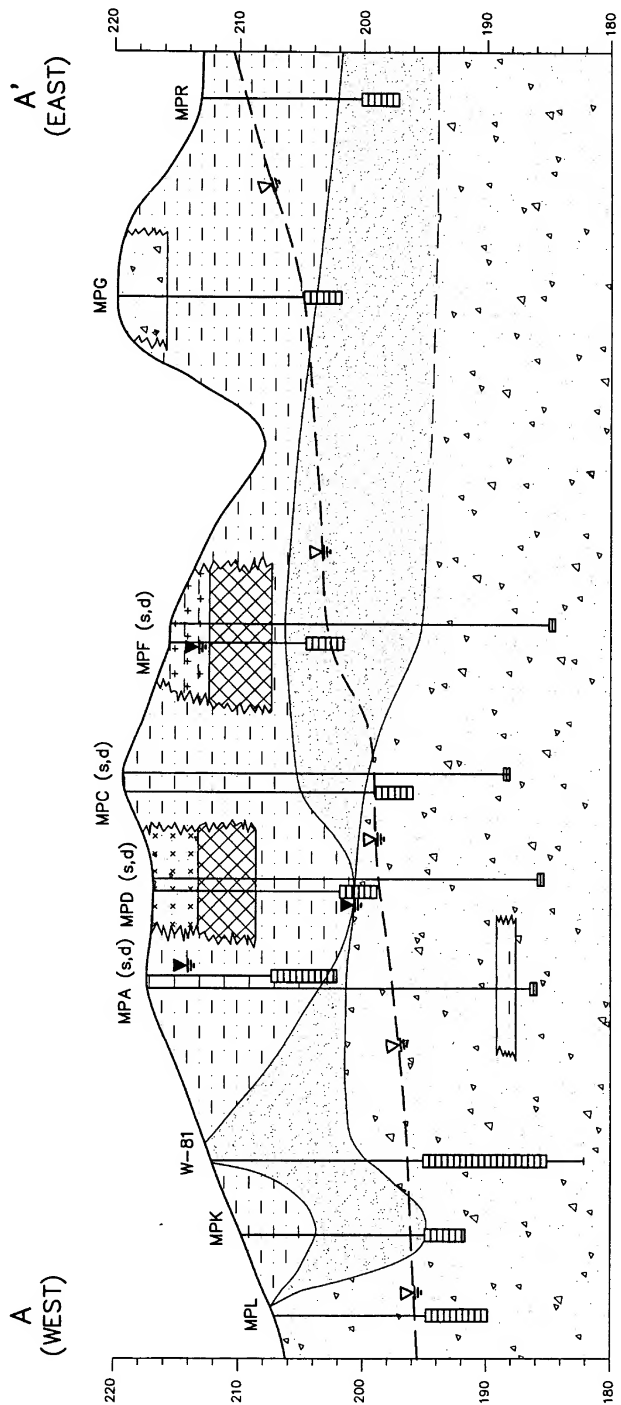
Characterization of the subsurface sediments has been the objective of several investigations; the site geology and hydrogeology descriptions presented below were principally derived from a previous Site Inspection Report (CH2M Hill, 1995) and the current investigation. There are currently nine groundwater monitoring wells associated with LF-06 (Figure 3.2). As part of the current investigation, twenty-one monitoring points were installed at seventeen locations using a Geoprobe®.

3.3.1 Lithology and Stratigraphic Relationships

Surface sediments at the site primarily consist of the upper terrace Prentiss-Rosella-Steens Association, which is composed of sand, silt, and clay loams. The sediments range from 0 to 18 feet in thickness at the site, and overlie approximately 40 feet of lower terrace and alluvial deposits composed of alluvial sand and gravel. In turn, the lower terrace and alluvial deposits overlie coastal plain clay and sandy clay deposits.

To illustrate these stratigraphic relationships, hydrogeologic sections have been developed from subsurface data derived from logs of previously installed monitoring wells and from the November 1996 Geoprobe® investigation. Figure 3.2 shows the locations of these sections. Figure 3.3 presents the hydrogeologic section A-A', which is oriented approximately parallel to the direction of groundwater flow. Figure 3.4 presents the hydrogeologic section B-B', which is oriented approximately perpendicular to the direction of groundwater flow. In general, hydrogeologic sections A-A' and B-B' depict 0 to 18 feet





LEGEND

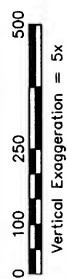
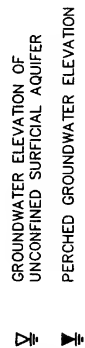
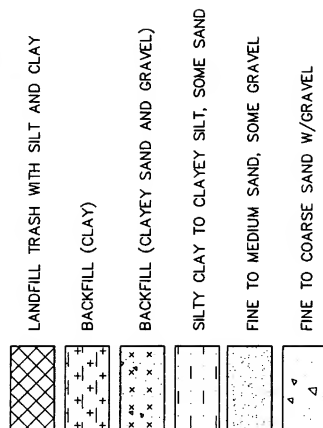


FIGURE 3.3

HYDROGEOLOGIC CROSS-SECTION A-A'

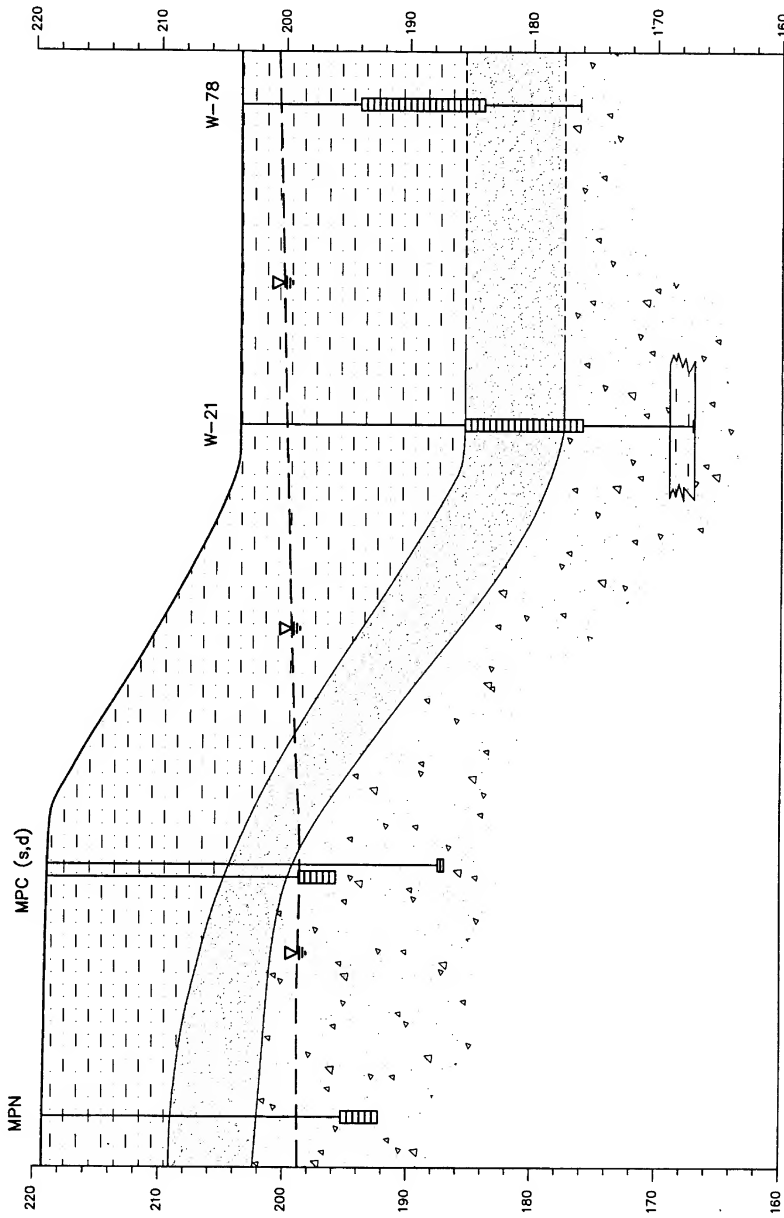
Site LF-06 RNA TS
Columbus AFB, Mississippi

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

B
(NORTH)

B
(SOUTH)



LEGEND

- SILTY CLAY TO CLAYEY SILT, SOME SAND
- FINE TO MEDIUM SAND, SOME SILT AND GRAVEL
- FINE TO COARSE SAND W/GRAVEL
- GROUNDWATER ELEVATION OF UNCONFINED SURFICIAL AQUIFER

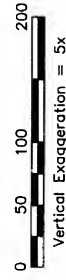


FIGURE 3.4

HYDROGEOLOGIC
CROSS-SECTION B-B'

Site LF-06 RNA TS
Columbus AFB, Mississippi

**PARSONS
ENGINEERING SCIENCE, INC.**
Denver, Colorado

of silty and clayey soils overlying 1 to 10 feet of fine to medium sand, which in turn, overlies fine to coarse sand with gravel.

3.3.2 Groundwater Hydraulics

The water table at the site is located in both the silty and clayey soils and the sandy Quaternary sediments of the unconfined surficial aquifer. Depth to groundwater is approximately 5 to 21 feet bgs across the site. However, perched water occurs in wells screened above the shallow potentiometric surface, possibly resulting from the presence of landfill trash. Perched water occurs in wells MPA(s), MPB, MPD(s), MPF(s), MPH, and MPJ. These perched levels range from approximately 2.5 ft to 16.5 ft above the groundwater surface measured by deeper wells (Figure 3.3). A summary of groundwater measurements from November 1996 is presented in Table 3.1. The reference point elevations measured in November 1996 for wells W-18, W-20, and W-22 were 0.3 feet higher than the elevations measured for these wells in 1989. Because reference point elevations for wells W-19, W-21, W-78, and W-79 were not surveyed during the November 1996 field effort, these elevations were estimated by adding a bias of 0.3 ft to top-of-casing elevations from a survey conducted by CH2M Hill in 1989 to align them with the reference points surveyed in 1996. Reference point elevations for wells W-81 and W-82 were obtained from a survey corresponding with their installation in 1994 by CH2M Hill. Construction details for temporary monitoring points and monitoring wells are presented in Appendix A.

3.3.2.1 Flow Direction and Gradient

Figure 3.5 shows groundwater elevations for LF-06 in November 1996. Due to perched groundwater levels, data from wells MPA(s), MPB, MPD(s), MPF(s), MPH, and MPJ were not used for contouring. Groundwater flows to the west with a nonuniform gradient ranging from 0.003 foot per foot (ft/ft) to 0.027 ft/ft, and averages 0.0055 ft/ft across the site. The gradient is consistent with values observed in December 1988 and May 1989 (CH2M Hill, 1989), and with values observed in February 1995 and December

TABLE 3.1
SUMMARY OF GROUNDWATER ELEVATION DATA
NOVEMBER 1996
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

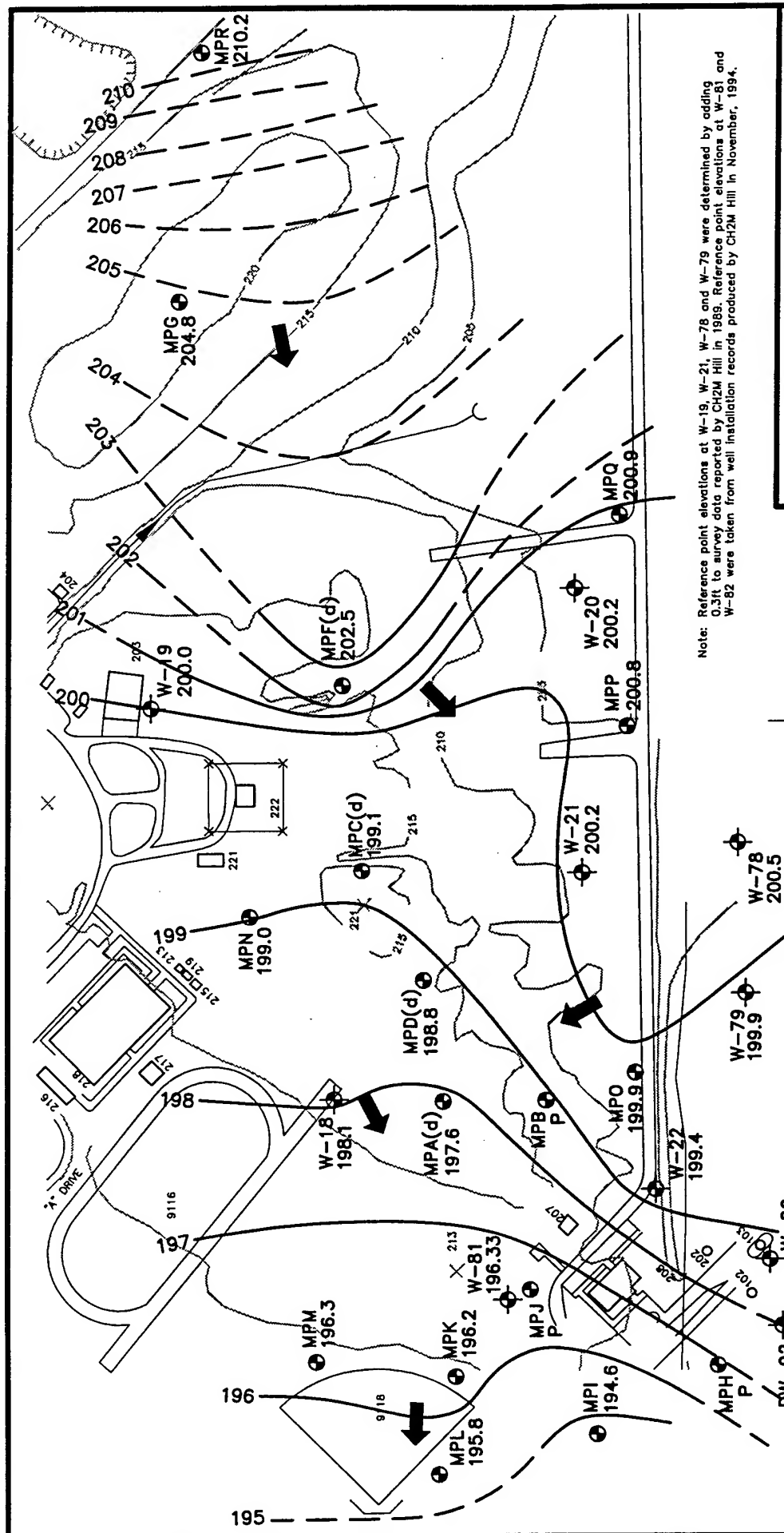
Well Identification	Elevation of Reference Point for Measurements (feet msl) ^{a/}	Depth to Groundwater (feet)	Groundwater Elevation (feet msl)
W-18	215.6	17.5	198.1
W-19	219.0 ^{b/}	19.0	200.0
W-20	205.6	5.4	200.2
W-21	207.2 ^{b/}	7.0	200.2
W-22	208.7	9.3	199.4
W-78	206.8 ^{b/}	6.3	200.5
W-79	208.0 ^{b/}	8.1	199.9
W-81	212.2 ^{c/}	15.9	196.3
W-82	207.2 ^{c/}	8.5	198.7
MPA (s)	216.7	2.6	214.1*
MPA (d)	217.7	20.1	197.6
MPB	211.9	4.3	207.6*
MPC (s)	218.7	19.8	199.0
MPC (d)	219.9	20.8	199.1
MPD (s)	216.5	15.6	200.9*
MPD (d)	217.6	18.8	198.8
MPF (s)	215.0	1.9	213.1*
MPF (d)	216.0	13.5	202.5
MPG	219.3	14.5	204.8
MPH	208.6	4.1	204.5*
MPI	206.7	12.1	194.6
MPJ	213.4	12.6	200.8*
MPK	209.3	13.2	196.2
MPL	206.6	10.8	195.8
MPM	208.5	12.3	196.3
MPN	219.1	20.1	199.0
MPO	203.6	3.7	199.9
MPP	204.9	4.1	200.8
MPQ	204.3	3.4	200.9
MPR	212.7	2.5	210.2

^{a/} Feet msl = feet above mean sea level.

^{b/} Reference point elevation determined by adding 0.3 ft to survey data reported by CH2M Hill in 1989.

^{c/} Reference point elevation obtained from well installation records produced by CH2M Hill in November 1994.

* Perched groundwater - not used for contouring.



Note: Reference point elevations at W-19, W-21, W-78 and W-79 were determined by adding 0.3ft to survey data reported by CH2M Hill in 1989. Reference point elevations at W-81 and W-82 were taken from well installation records produced by CH2M Hill in November, 1994.

FIGURE 3.5

WATER TABLE ELEVATIONS NOVEMBER 1996

Site LF-06 RNA TS
Columbus AFB, Mississippi

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado

LEGEND

MPK 16.2 MONITORING POINT WITH WATER TABLE ELEVATION (ft msl)

W-78 200.5 MONITORING WELL WITH WATER TABLE ELEVATION (ft msl)

(d) GROUNDWATER ELEVATION MEASURED IN DEEP MONITORING POINT

P PERCHED GROUNDWATER

INFERRED DIRECTION OF GROUNDWATER FLOW

NA DATA NOT AVAILABLE

1995 (Spencer, 1996a, 1996b). The heads from November 1996 are approximately 1 to 4 feet lower than during the previous sampling events. This variation may be due to seasonal fluctuations in recharge.

One groundwater monitoring point well pair installed for this investigation was used to evaluate vertical hydraulic gradients at LF-06. Because MPA(s), MPD(s), and MPF(s) were not screened below the potentiometric surface, groundwater elevations at these wells represent perched conditions and therefore could not be used to calculate a vertical gradient. Groundwater elevation data collected in November 1996 at monitoring point pair MPC(s)/MPC(d) indicated that a no vertical gradient was not present.

3.3.2.2 Hydraulic Conductivity

In November 1996, Parsons ES conducted falling- and rising-head slug tests at wells W18, W19, W22, W79, W81, and W82. Hydraulic conductivity was calculated using the method of Bower and Rice (1976), as described in Section 2. The average of the falling and rising head test results of these slug tests are summarized in Table 3.2. Hydraulic conductivities ranged from 16 ft/day to 238 ft/day, with an average hydraulic conductivity of 99 ft/day. The slug-test analyses are presented in Appendix A.

TABLE 3.2
1996 SLUG TEST RESULTS
SITE LF-06
RNA TS
COLUMBUS AFB, MISSISSIPPI

WELL	HYDRAULIC CONDUCTIVIT Y (ft/min)	HYDRAULIC CONDUCTIVITY (ft/day)
W18	0.050	72
W19	0.021	30
W22	0.126	181
W79	0.011	16
W81	0.165	238
W82	0.040	58

3.3.2.3 Effective Porosity

Because of the difficulty involved in accurately determining effective porosity, published literature values for soil types comprising the shallow saturated zone were referenced (Walton, 1988; Domenico and Schwartz, 1990). Estimates of effective porosity for fine to medium sand with gravel range from 0.08 to 0.30. An average effective porosity of 0.25 was assumed for the shallow surficial aquifer at Site LF-06.

3.3.2.4 Advective Groundwater Velocity

The advective velocity of groundwater in the direction parallel to groundwater flow is given by:

$$\bar{v} = \frac{K}{n_e} \frac{dH}{dL}$$

Where: \bar{v} = Average advective groundwater velocity (seepage velocity)
[L/T]

K = Hydraulic conductivity [L/T] (99 ft/day)

dH/dL = Gradient [L/L] (0.0055 ft/ft)

n_e = Effective porosity (0.25).

Using this relationship in conjunction with site-specific data, the average advective groundwater velocity across the site in November 1996 was 2.2 ft/day, or approximately 795 feet per year (ft/yr).

3.3.2.5 Preferential Flow Paths

No preferential contaminant migration pathways were identified during the field work phase of this project. Parts of the sanitary sewer system, electrical distribution system, water supply system, and storm drainage system extend onto the site, but are not anticipated to influence migration pathways because of the high hydraulic conductivities associated with native surficial aquifer materials.

3.3.3 Groundwater Use

Groundwater in the shallow aquifer is not used as a local source of potable water within the vicinity of the site. There are five deep on-Base wells that provide potable water to Columbus AFB. The only downgradient well, at Building 363, is located approximately 3,000 feet west of the Site. This well is screened at a depth of 386 to 426 feet bgs within the Tuscaloosa Group of the Eutaw Aquifer. Wells at Buildings 604 and 865 are located 3,000 and 4,500 feet northwest of the Site, respectively. These wells are screened at depths of 396 to 443 feet bgs and 430 to 470 feet bgs within the Tuscaloosa Group of the Eutaw Aquifer, respectively. Columbus AFB plans to connect to the City of Columbus water system in 1997, and subsequently abandon these three wells (Stewart, 1997). Two other wells of unknown depth, at Buildings 1812 and 2052, supply drinking water at their respective locations. These wells are located approximately 11,000 feet to the northwest and 7,000 feet to the north of the site. The four closest private wells, Wells R-55, R-56, R-53, and R-57 are located 3,100 feet to the south, 3,500 feet to the southeast, 3,800 feet to the south, and 4,200 feet to the southeast of the Site, respectively. The closest private well downgradient of the Site, Well R-85, is located 10,000 feet from the site. Private wells R-55 and R-85 are screened in the Eutaw Aquifer. Private wells R-56, R-53, and R-57 are of unknown depth (CH2M Hill, 1989).

3.4 CLIMATE

The climate in northeastern Mississippi is typified by short, cool winters and hot, humid summers. Precipitation averages 56 inches per year, and is evenly distributed throughout the year.

SECTION 4

CONTAMINANT DISTRIBUTION AND EVIDENCE FOR BIODEGRADATION

Soil and groundwater have been contaminated as a result of disposal activities at LF-06. Work during the RI (CH2M Hill, 1989) focused on defining the nature and extent of contamination at the site, and additional monitoring has recently been conducted at the site (Spencer, 1996a). As needed, the data collected during those efforts is used to supplement the data collected during the field phase of this work, presented in the following subsections. In particular, this section focuses on data useful for evaluating and modeling natural attenuation of fuel hydrocarbons and chlorinated solvents dissolved in groundwater.

4.1 CONTAMINANT SOURCES AND SOIL CHEMISTRY

4.1.1 Contaminant Sources

Sources of dissolved groundwater contamination at LF-06 are not clearly defined. It is likely that material disposed in the trenches is the original source of groundwater contamination. However, the exact locations and nature of the releases is not clear from the available data. The low concentrations of dissolved contaminants discussed in Section 4.3 suggest that the presence of a mobile NAPL source is unlikely. In addition, residual NAPL bodies have not been identified or delineated during either previous or current subsurface investigations; therefore, the dissolved contaminant data must be used to infer sources, and as discussed in Section 4.3, these data also suggest that residual sources are relatively small and localized.

A total of 4 soil samples were collected from 3 Geoprobe® boreholes (MPF, MPI, and MPL) in 1996. These samples were analyzed for fuel hydrocarbons and chlorinated

solvents. The results are summarized in Table 4.1. No contaminants were detected in the samples from MPJ and MPL. Fuel-related compounds were detected in two of the samples, both collected from MPF. In the sample from a depth of 4 to 8 feet bgs, the total BTEX concentration was 373 micrograms per kilogram ($\mu\text{g/kg}$) [0.373 milligrams per kilogram (mg/kg)], and the total recoverable petroleum hydrocarbons (TRPH) concentration was 760 mg/kg . The high proportion of TRPH relative to BTEX suggests that the residual soil contamination in this area consists partially of weathered motor fuel or jet fuel, if not motor oil or waste oil. These detections also suggest that a source of groundwater contamination is present in the vicinity of MPF, possibly related to the apparent burial trench just east of MPF (Figure 2.1). The sample from a depth of 8 to 10 feet bgs in MPF contained toluene at a concentration of 1.4 $\mu\text{g/kg}$.

Chlorinated compounds also were detected in both samples from MPF. In the shallow sample, chlorobenzene (CB) was detected at a concentration of 4,900 $\mu\text{g/kg}$, while 1,2-dichlorobenzene (1,2-DCB) and 1,3-DCB were detected at concentrations of 7.7 $\mu\text{g/kg}$ and 12 $\mu\text{g/kg}$, respectively. In the deeper sample, CB was detected at a concentration of 2J $\mu\text{g/kg}$. Also, vinyl chloride (VC) and dichloromethane were detected at low concentrations (less than 2 $\mu\text{g/kg}$) in the shallow sample, but the presence of these compounds could not be confirmed by the laboratory's mass spectrometer.

4.1.2 Total Organic Carbon in Soil

Total organic carbon (TOC) concentrations are used to estimate the amount of organic matter sorbed to soil particles or trapped in the interstitial passages of a soil matrix. The TOC concentration in the saturated zone is an important parameter used to estimate the amount of contaminant that could potentially be sorbed to the aquifer matrix. Sorption results in retardation of the contaminant plume relative to the average advective groundwater velocity. In addition, TOC can be used as a gross indicator of organic compounds that are available as a source of carbon and electron donors (or substrate) for a microbial population.

TABLE 4.1
SOIL ANALYTICAL DATA
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Sample ID	Date Sampled	Depth (feet bgs ^{a/})	Benzene (µg/kg ^{b/})	Toluene (µg/kg)	Ethylbenzene (µg/kg)	Xylenes (µg/kg)	Total BTEX (µg/kg)	1,3,5-TMB (µg/kg)	1,2,4-TMB (µg/kg)	1,2,3-TMB (µg/kg)	1,2,3,4-TEMB (µg/kg)	TRPH (mg/kg ^{c/})	CB (µg/kg)	1,2-DCB (µg/kg)	1,3-DCB (µg/kg)
MPF	11/15/96	4-8	69	10	84	210	373	89	240	110	190	760	4,900	7.7	12
MPF ^{d/}	11/15/96	8-10	ND ^{e/}	1.4	ND	ND	1.4	ND	ND	ND	ND	ND	2J ^{f/}	ND	ND
MPJ	11/8/96	18	NA ^{g/}	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND
MPL	11/9/96	14-18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

^{a/} bgs = below ground surface.

^{b/} µg/kg = micrograms per kilogram.

^{c/} mg/kg = milligrams per kilogram.

^{d/} Also detected in this sample were VC and dichloromethane; however, the presence of these compounds could not be confirmed by mass spectrometer.

^{e/} ND = Analyte not detected.

^{f/} J = Estimated value.

^{g/} NA = Not analyzed.

Note: BTEX = benzene, toluene, ethylbenzene, and xylenes; TMB = trimethylbenzene; TEMB = tetramethylbenzene; CB = chlorobenzene; and DCB = dichlorobenzene.

Soil TOC concentrations were measured in 2 samples from 2 Geoprobe® locations in 1996. These samples were collected from a depth of 18 feet in the borehole for MPJ and from a depth of 14 to 18 feet in the borehole for MPL. Both samples were collected from below the water table or in the capillary fringe. In both samples, soil TOC concentrations were reported to be less than 0.06 percent.

Despite the fact that reported soil TOC concentrations are below 0.06 percent, sorption may play an important role in dissolved contaminant attenuation. For BTEX compounds and most of the chlorinated solvents detected at LF-06 (the notable exception being VC), retardation of contaminant migration is significant when TOC concentrations are on the order of 0.01 percent. The method detection limit was used as an approximation of TOC levels in site soils for modeling purposes. Even though it is unclear whether soil TOC levels are significantly less than 0.06 percent, it is expected that some sorption, and therefore some contaminant retardation with respect to groundwater velocity, is occurring.

4.2 OVERVIEW OF HYDROCARBON BIODEGRADATION

Mechanisms for natural attenuation of chlorinated solvents and BTEX include biodegradation, dispersion, dilution from recharge, sorption, and volatilization. Of these processes, biodegradation is the only mechanism working to transform contaminants into ultimately innocuous byproducts. Intrinsic bioremediation occurs when indigenous microorganisms work to bring about a reduction in the total mass of contamination in the subsurface without the addition of nutrients. In order to provide a foundation for interpreting site data, the following subsections review the major bioremediation processes that act upon chlorinated solvents and BTEX.

BTEX compounds and several chlorinated solvents are present in groundwater at LF-06. As a result, the following sections discuss the biodegradation of both BTEX and chlorinated solvents. Because the terminology describing biodegradation of both types of compounds is similar, a generalized review of the processes is presented first.

4.2.1 Review of Biodegradation Processes

Microorganisms obtain energy for cell production and maintenance by facilitating thermodynamically advantageous redox reactions involving the transfer of electrons from electron donors to available electron acceptors. This results in the oxidation of the electron donor and the reduction of the electron acceptor. Electron donors may be natural organic carbon, fuel hydrocarbon compounds, and less-chlorinated solvents [e.g., VC, dichloroethene (DCE), dichloroethane (DCA), or chlorinated benzenes ranging from CB to tetrachlorobenzene]. Fuel hydrocarbons or solvents are completely degraded or detoxified if they are utilized as the primary electron donor (i.e., as a primary substrate or carbon source) for microbial metabolism (Bouwer, 1992). Electron acceptors are elements or compounds that occur in relatively oxidized states, and include oxygen, nitrate, ferric iron, sulfate, manganese, carbon dioxide, and highly chlorinated solvents [e.g., tetrachloroethene (PCE), trichloroethene (TCE), tetrachloroethane (PCA), trichloroethane (TCA), and polychlorinated benzenes].

The driving force of biodegradation is electron transfer, which is quantified by the Gibbs free energy of the reaction (ΔG°_r) (Stumm and Morgan, 1981; Bouwer, 1994; Godsey, 1994). The value of ΔG°_r represents the quantity of free energy consumed ($\Delta G^\circ_r > 0$) or yielded ($\Delta G^\circ_r < 0$) to the system during the reaction. Although thermodynamically favorable, most of the reactions involved in biodegradation of fuel hydrocarbons or chlorinated hydrocarbons cannot proceed abiotically because of the lack of activation energy. Microorganisms are capable of providing the necessary activation energy; however, they will facilitate only those redox reactions that have a net yield of energy (i.e. $\Delta G^\circ_r < 0$). Most reactions involving biodegradation of contaminants do yield energy to the microbes; however, in many cases specific geochemical conditions are necessary for this reaction to be favorable and to allow the appropriate microbial population to develop and grow.

Microorganisms preferentially utilize electron acceptors while metabolizing hydrocarbons (Bouwer, 1992). DO is utilized first as the prime electron acceptor. It is under these conditions (i.e., aerobic conditions) that fuel hydrocarbons and the less chlorinated solvents are most commonly used as electron donors. After the DO is consumed, anaerobic microorganisms use native electron acceptors in the following order of preference: nitrate, manganese, ferric iron hydroxide, sulfate, and finally carbon dioxide. Under anaerobic conditions, BTEX compounds and other fuel hydrocarbons are still used as electron donors. Chlorinated solvents that are amenable to reductive dehalogenation are generally used as electron acceptors when aquifer conditions are such that sulfate or carbon dioxide is the preferred electron acceptor.

In addition to being controlled by the energy yield of the reaction, the expected sequence of redox processes is also a function of the oxidizing potential of the groundwater. This potential is a measure of the relative tendency of a solution or chemical reaction to accept or transfer electrons. As each subsequent electron acceptor is utilized, the groundwater becomes more reducing, and the redox potential of the water decreases. The main force driving this change in redox potential is microbially mediated redox reactions. Redox potential can be used as an indicator of which redox reactions may be operating at a site. Environmental conditions and microbial competition ultimately determine which processes will dominate.

Depending on the types and concentrations of electron acceptors present (e.g., nitrate, sulfate, carbon dioxide), pH conditions, and redox potential, anaerobic biodegradation can occur by denitrification, manganese reduction, ferric iron reduction, sulfate reduction, or methanogenesis. Other, less common anaerobic degradation mechanisms such as manganese or nitrate reduction may dominate if the physical and chemical conditions in the subsurface favor use of these electron acceptors. Vroblesky and Chapelle (1994) show that the dominant terminal electron accepting process can vary both temporally and spatially in an aquifer with fuel hydrocarbon contamination.

4.2.2 Biodegradation of BTEX

Numerous laboratory and field studies have shown that hydrocarbon-degrading bacteria can participate in the degradation of many of the chemical components of fuel hydrocarbons, including the BTEX compounds (e.g., Jamison *et al.*, 1975; Atlas, 1981, 1984, 1988; Gibson and Subramanian, 1984; Reinhard *et al.*, 1984; Young, 1984; Bartha, 1986; Wilson *et al.*, 1986, 1987, and 1990; Barker *et al.*, 1987; Baedeker *et al.*, 1988; Lee, 1988; Chiang *et al.*, 1989; Grbic-Galic, 1989 and 1990; Cozzarelli *et al.*, 1990; Leahy and Colewell, 1990; Altenschmidt and Fuchs, 1991; Alvarez and Vogel, 1991; Baedeker and Cozzarelli, 1991; Ball *et al.*, 1991; Bauman, 1991; Borden, 1991; Brown *et al.*, 1991; Edwards *et al.*, 1991 and 1992; Evans *et al.*, 1991a and 1991b; Haag *et al.*, 1991; Hutchins and Wilson, 1991; Hutchins *et al.*, 1991a and 1991b; Beller *et al.*, 1992; Bouwer, 1992; Edwards and Grbic-Galic, 1992; Thierrin *et al.*, 1992; Malone *et al.*, 1993; Davis *et al.*, 1994). Fuel hydrocarbons biodegrade naturally when an indigenous population of hydrocarbon-degrading microorganisms is present in the aquifer and sufficient concentrations of electron acceptors and nutrients are available to these organisms.

During biodegradation of fuel hydrocarbons, the fuel compounds are used as electron donors. They are the primary substrate ("food") for the microbes, while the electron acceptors provide the oxidant used to reduce (metabolize) the substrate and produce energy. In most subsurface environments, both aerobic and anaerobic degradation of fuel hydrocarbons can occur, often simultaneously in different parts of the plume. The nearly ubiquitous nature of these processes is well documented (e.g., Rice *et al.*, 1995; Wiedemeier *et al.*, 1995; Kuehne and Busheck, 1996; and Mace *et al.*, 1997). Aerobic destruction of BTEX compounds dissolved in groundwater results in the consumption (reduction) of DO and the formation of carbon dioxide. Anaerobic destruction of the BTEX compounds is associated with the accumulation of fatty acids, production of methane, solubilization of iron, and reduction of nitrate and sulfate (Cozzarelli *et al.*, 1990; Wilson *et al.*, 1990).

4.2.3 Biodegradation of Chlorinated Solvents

Chlorinated solvents can be transformed, directly or indirectly, by biological processes (e.g., Bouwer *et al.*, 1981; Miller and Guengerich, 1982; Reineke and Knackmuss, 1984; Wilson and Wilson, 1985; de Bont *et al.*, 1986; Nelson *et al.*, 1986; Spain and Nishino, 1987; Bouwer and Wright, 1988; Little *et al.*, 1988; Mayer *et al.*, 1988; Arciero *et al.*, 1989; Cline and Delfino, 1989; Freedman and Gossett, 1989; Folsom *et al.*, 1990; Harker and Kim, 1990; Alvarez-Cohen and McCarty, 1991a, 1991b; DeStefano *et al.*, 1991; Henry, 1991; Sander *et al.*, 1991; McCarty *et al.*, 1992; Hartmans and de Bont, 1992; Chapelle, 1993; McCarty and Semprini, 1994; Vogel, 1994; Suflita and Townsend, 1995; Bradley and Chapelle, 1996; Klier *et al.*, 1996; Spain, 1996). Biodegradation of chlorinated solvents, also termed chlorinated aliphatic hydrocarbons (CAHs) and chlorinated benzenes results from the same general processes that bring about biodegradation of fuel hydrocarbons. However, a more complex series of processes often is involved, and CAHs and chlorinated benzenes may act as either substrates (electron donors) or electron acceptors depending upon what geochemical conditions prevail.

Whereas BTEX are biodegraded in essentially one step by acting as an electron donor/carbon source, CAHs and chlorinated benzenes may undergo several types of biodegradation involving several steps. Chlorinated solvents may undergo biodegradation through three different pathways: use as an electron acceptor, use as an electron donor, or cometabolism, which is degradation resulting from exposure to a catalytic enzyme fortuitously produced during an unrelated process. At a given site, one or all of these processes may be operating, although at many sites the use of CAHs as electron acceptors appears to be the most likely.

In a pristine aquifer, native organic carbon is utilized as an electron donor and DO is utilized first as the prime electron acceptor. Where anthropogenic carbon (e.g., fuel hydrocarbons, less-chlorinated CAHs, or chlorinated benzenes with four or fewer chlorines) is present, it also may be utilized as an electron donor. Most chlorinated

solvents that can act as electron donors have thus far only been demonstrated to do so under aerobic conditions, with the notable exception of VC (Bradley and Chapelle, 1996). After the DO is consumed, anaerobic microorganisms typically use native electron acceptors (as available) in the following order of preference: nitrate, ferric iron oxyhydroxide, sulfate, and finally carbon dioxide. Evaluation of the distribution of these electron acceptors can provide evidence of where and how biodegradation of chlorinated solvents is occurring. In addition, because solvents may be used as electron acceptors or electron donors (in competition with other acceptors or donors), isopleth maps showing the distribution of these compounds also will provide evidence of the types of biodegradation processes acting at a site. A more complete description of the main types of biodegradation reactions affecting chlorinated solvents dissolved in groundwater is presented in the following subsections.

4.2.3.1 Electron Acceptor Reactions (Reductive Dehalogenation)

Under anaerobic conditions, biodegradation of chlorinated solvents usually proceeds through a process called reductive dehalogenation. During this process, the halogenated hydrocarbon is used as an electron acceptor, not as a source of carbon, and a halogen atom is removed and replaced with a hydrogen atom. As an example, Figure 4.1 illustrates the transformation of chlorinated ethenes via reductive dehalogenation. In general, reductive dehalogenation of chlorinated ethenes occurs by sequential dehalogenation from PCE to TCE to DCE to VC to ethene. An analogous pattern for chlorinated ethanes might be PCA to TCA to DCA to CA, and for chlorinated benzenes the pattern might be tetrachlorobenzene (TeCB) to trichlorobenzene (TCB) to DCB to CB. Depending upon environmental conditions, these sequences may be interrupted, with other processes (e.g.,

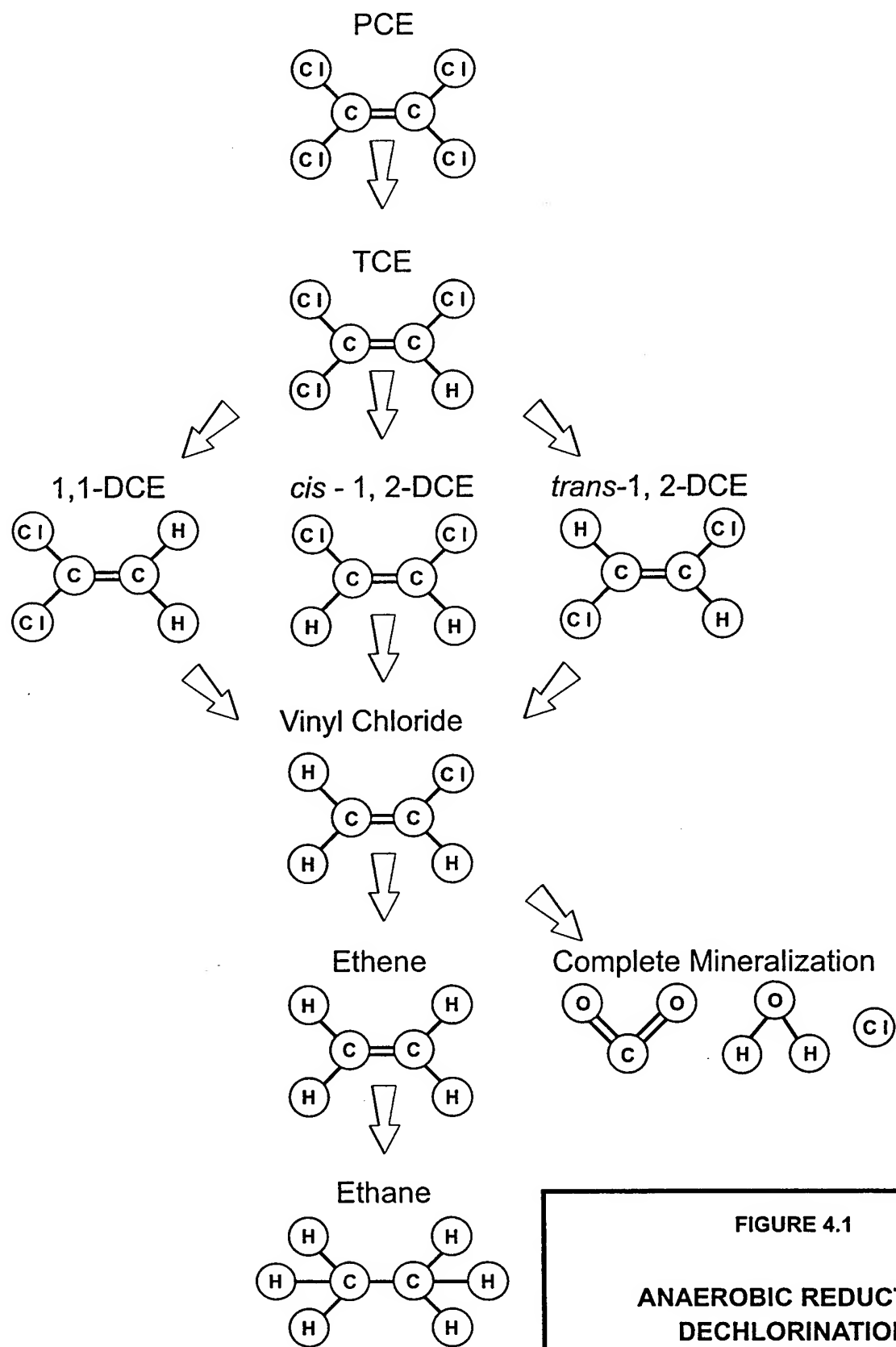


FIGURE 4.1

**ANAEROBIC REDUCTIVE
DECHLORINATION**

LF-06 RNA TS
Columbus AFB, Mississippi

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

aerobic or abiotic degradation) then acting upon the products. Reductive dehalogenation of chlorinated solvent compounds is associated with the accumulation of daughter products and an increase in chloride.

Reductive dehalogenation affects chlorinated compounds differently. Of the ethenes, PCE is the most susceptible to reductive dehalogenation because it is the most oxidized. Conversely, VC is the least susceptible to reductive dehalogenation because it is the least oxidized of these compounds. Likewise, hexachlorobenzene is more susceptible to reductive dehalogenation than less-chlorinated benzenes. In general, the rate of reductive dehalogenation of chlorinated solvents has been observed to decrease as the degree of chlorination decreases (Vogel and McCarty, 1985; Bouwer, 1994). Murray and Richardson (1993) have postulated that this rate decrease may explain the accumulation of VC in PCE and TCE plumes that are undergoing reductive dehalogenation.

In addition to being affected by the degree of chlorination of the compound, reductive dehalogenation also can be controlled by the redox conditions of the site groundwater system. In general, reductive dehalogenation has been demonstrated under anaerobic nitrate- and sulfate-reducing conditions, but the most rapid biodegradation rates, affecting the widest range of compounds, occur under methanogenic conditions (Bouwer, 1994). Dehalogenation of PCE and TCE to DCE can proceed under mildly reducing conditions such as nitrate reduction or iron (III) reduction (Vogel *et al.*, 1987), while the transformation of DCE to VC, or the transformation from VC to ethene requires more strongly reducing conditions (Freedman and Gossett, 1989; DeStefano *et al.*, 1991; De Bruin *et al.*, 1992).

Reductive dehalogenation of some compounds also has been shown to preferentially produce specific daughter compounds. For example, during reductive dehalogenation of TCE or PCE, all three isomers of DCE can theoretically be produced; however, Bouwer (1994) reports that under the influence of biodegradation, *cis*-1,2-DCE is a more common

intermediate than *trans*-1,2-DCE, and that 1,1-DCE is the least prevalent intermediate of the three DCE isomers.

When chlorinated compounds are used as electron acceptors, there must be an appropriate source of carbon for microbial growth in order for reductive dehalogenation to occur (Bouwer, 1994). Potential carbon sources/electron donors can include low-molecular-weight compounds (e.g., lactate, acetate, methanol, or glucose) present in natural organic matter, fuel hydrocarbons, or less-chlorinated solvents (as discussed below).

4.2.3.2 Electron Donor Reactions

Under aerobic conditions some chlorinated solvents can be utilized as the primary substrate (i.e., electron donor) in biologically mediated redox reactions (McCarty and Semprini, 1994). In this type of reaction, the facilitating microorganism obtains energy and organic carbon from the degraded compound. In contrast to reactions in which the chlorinated compound is used as an electron acceptor, only the least oxidized chlorinated solvents (e.g., VC, DCE, or chlorobenzene) may be utilized as electron donors in biologically mediated redox reactions. Also, chlorinated benzenes with up to four chlorines (i.e., CB, DCB isomers, TCB isomers, and TeCB isomers) have been shown to act as electron donors under aerobic conditions.

For example, while Murray and Richardson (1993) write that microorganisms are generally believed to be incapable of growth using TCE and PCE, other less chlorinated CAHs have been shown to be used as substrates. Davis and Carpenter (1990) describe the aerobic oxidation of VC in groundwater. McCarty and Semprini (1994) describe investigations in which VC and 1,2-DCA were shown to serve as primary substrates. These authors also document that dichloromethane has the potential to function as a primary substrate under either aerobic or anaerobic environments. Klier *et al.* (1996) describe aerobic mineralization of all three isomers of DCE. In addition, Bradley and

Chapelle (1996) show evidence of oxidation of VC under iron-reducing conditions so long as there is sufficient bioavailable iron (III). Aerobic metabolism of VC may be characterized by a loss of VC mass, a decreasing molar ratio of VC to other CAH compounds, and rarely, the presence of chloromethane.

CB and polychlorinated benzenes (up to and including TeCB) have been shown to be biodegradable under aerobic conditions. Several studies have shown that bacteria are able to utilize CB (Reineke and Knackmuss, 1984), 1,4-DCB (Reineke and Knackmuss, 1984; Schraa *et al.*, 1986; Spain and Nishino, 1987), 1,3-DCB (de Bont *et al.*, 1986), 1,2-DCB (Haigler *et al.*, 1988), 1,2,4-TCB (van der Meer *et al.*, 1987; Sander *et al.*, 1991), and 1,2,4,5-TeCB (Sander *et al.*, 1991) as primary growth substrates in aerobic systems. Nishino *et al.* (1994) note that aerobic bacteria able to grow on chlorobenzene have been detected at a variety of chlorobenzene-contaminated sites, but not at uncontaminated sites. Spain (1996) notes that this provides strong evidence that the bacteria are selected for their ability to derive carbon and energy from chlorobenzene degradation *in situ*. The pathways for all of these reactions are similar, and are also similar to that of benzene (Chapelle, 1993; Spain, 1996). The only significant difference between aerobic oxidation of chlorobenzenes and benzene is the required elimination of chlorine. Anaerobic oxidation of chlorobenzenes has not been conclusively documented, although little work has been done on the subject (Spain, 1997).

4.2.3.3 Cometabolism

When a chlorinated solvent is biodegraded through cometabolism, it serves as neither an electron acceptor nor a primary substrate in a biologically mediated redox reaction. Instead, the degradation of the compound is catalyzed by an enzyme or cofactor that is fortuitously produced by organisms for other purposes. The organism receives no known benefit from the degradation of the solvent; rather the cometabolic degradation of the solvent may in fact be harmful to the microorganism responsible for the production of the enzyme or cofactor (McCarty and Semprini, 1994).

Cometabolism is best documented for chlorinated ethenes in aerobic environments, although it potentially could occur with other chlorinated solvents or under anaerobic conditions. Aerobic degradation pathways for chlorinated ethenes are illustrated in Figure 4.2. It has been reported that under aerobic conditions chlorinated ethenes, with the exception of PCE, are susceptible to cometabolic degradation (Murray and Richardson, 1993; Vogel, 1994; McCarty and Semprini, 1994). Vogel (1994) further elaborates that the cometabolism rate increases as the degree of dehalogenation decreases.

In the cometabolic process, TCE is indirectly transformed by bacteria as they use BTEX or another substrate to meet their energy requirements. Therefore, TCE does not enhance the degradation of BTEX or other carbon sources, nor will its cometabolism interfere with the use of electron acceptors involved in the oxidation of those carbon sources. Given this relationship, it would follow that depletion of suitable substrates (BTEX or other organic carbon sources) likely limits cometabolism of CAHs.

4.2.3.4 Behavior of Chlorinated Solvent Plumes

Chlorinated solvent plumes can exhibit three types of behavior depending on the amount of solvent, the amount of organic (native and/or anthropogenic) carbon in the aquifer, the distribution and concentration of natural electron acceptors, and the types of electron acceptors being utilized. Individual plumes may exhibit all three types of behavior in different portions of the plume. The different types of plume behavior are summarized below.

4.2.3.4.1 Type 1 Behavior

Type 1 behavior occurs where the primary substrate is anthropogenic carbon (e.g., BTEX or landfill leachate), and this anthropogenic carbon drives reductive dechlorination. When evaluating natural attenuation of a plume exhibiting type 1 behavior the following questions must be answered:

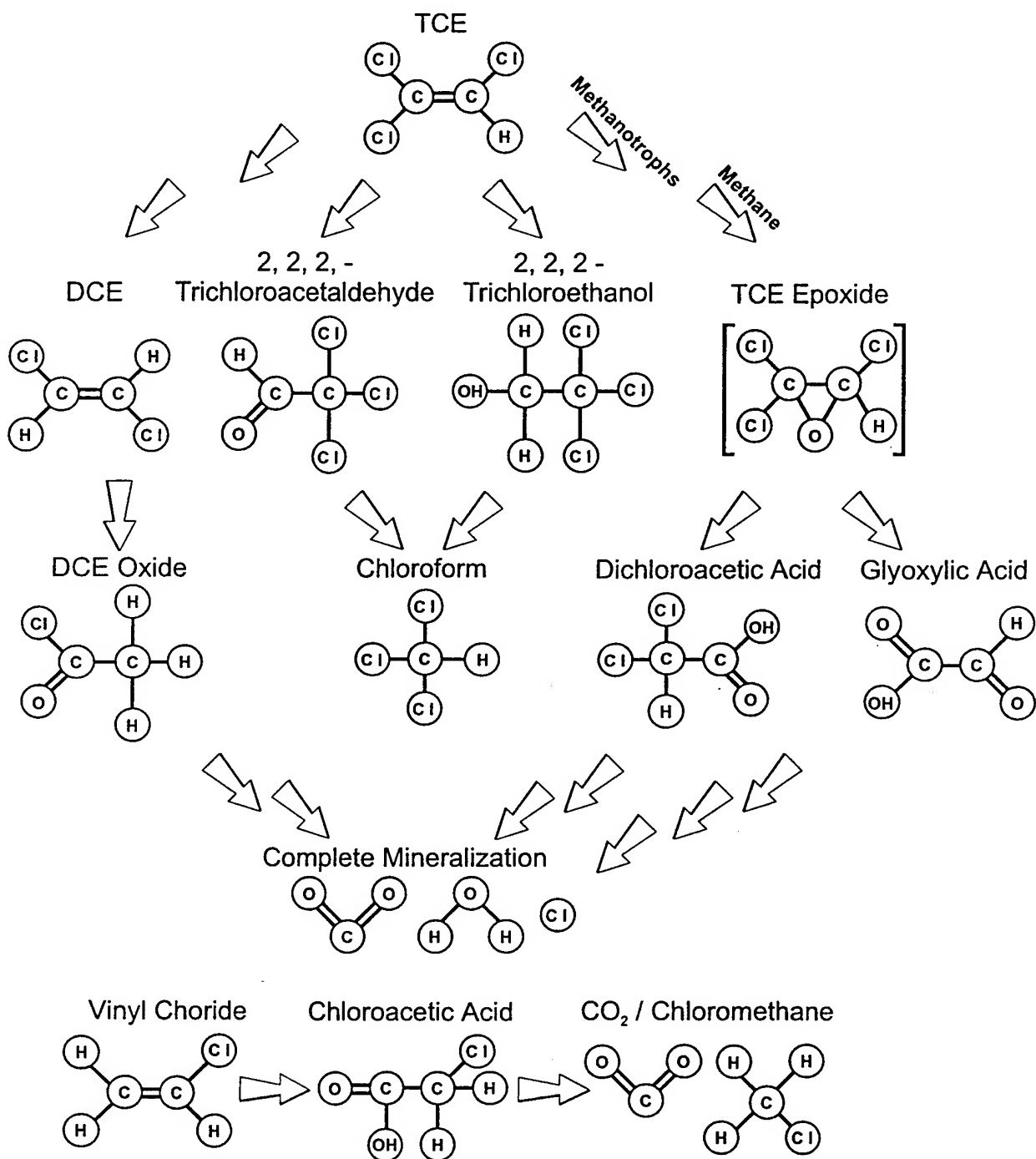


FIGURE 4.2

AEROBIC DECHLORINATION

LF-06 RNA TS
Columbus AFB, Mississippi

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

- 1) Is the electron donor supply adequate to allow microbial reduction of the chlorinated organic compounds? In other words, will the microorganisms "strangle" before they "starve" [i.e., will they run out of chlorinated aliphatic hydrocarbons (electron acceptors) before they run out of primary substrate (anthropogenic carbon)]?
- 2) What is the role of competing electron acceptors (e.g., DO, nitrate, iron (III) and sulfate)?
- 3) Are VC and other less-chlorinated solvents being oxidized, or are they being reduced?

Type 1 behavior results in the rapid and extensive degradation of the highly chlorinated solvents such as PCE, TCE, or polychlorinated benzenes.

4.2.3.4.2 Type 2 Behavior

Type 2 behavior dominates in areas that are characterized by relatively high concentrations of biologically available native organic carbon. This natural carbon source drives reductive dehalogenation (i.e., the primary substrate for microorganism growth is native organic carbon). When evaluating natural attenuation of a Type 2 chlorinated solvent plume, the same questions as those posed in the description of Type 1 behavior must be answered. Type 2 behavior generally results in slower biodegradation of the highly chlorinated solvents than Type 1 behavior, but under the right conditions (e.g., areas with high natural organic carbon contents), this type of behavior also can result in rapid degradation of these compounds.

4.2.3.4.3 Type 3 Behavior

Type 3 behavior dominates in areas that are characterized by low concentrations of native and/or anthropogenic carbon, and concentrations of DO that are greater than 1.0 mg/L. Under these aerobic conditions reductive dehalogenation will not occur. Thus there

is little or no removal of PCE and TCE. Biodegradation may proceed via the much slower process of cometabolism, but will be limited by the low concentrations of native or anthropogenic carbon. The most significant natural attenuation mechanisms for CAHs will be advection, dispersion, and sorption. However, VC can be rapidly oxidized under these conditions, DCE may be oxidized, CBs may be oxidized, and cometabolism also may occur.

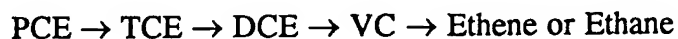
4.2.3.4.4 Mixed Behavior

As mentioned above, a single chlorinated solvent plume can exhibit all three types of behavior in different portions of the plume. This can be beneficial for natural biodegradation of chlorinated solvent plumes. For example, Wiedemeier *et al.* (1996a) describe a CAH plume at Plattsburgh AFB, New York that exhibits Type 1 behavior in the source area and Type 3 behavior downgradient from the source. The best scenario involves a plume in which PCE, TCE, and DCE are reductively dehalogenated (Type 1 or Type 2 behavior), then VC is oxidized (Type 3 behavior), either aerobically or via iron reduction. VC is oxidized to carbon dioxide in this type of plume and does not accumulate. The following sequence of reactions occurs in a plume that exhibits this type of mixed behavior:



In general, the TCE, DCE, and VC may attenuate at approximately the same rate, and thus these reactions may be confused with simple dilution. Note that no ethene is produced during this reaction. VC is removed from the system much faster under these conditions than it is under VC-reducing conditions.

A less desirable scenario, but one in which all contaminants may be entirely biodegraded, involves a plume in which all CAHs are reductively dehalogenated via Type 1 or Type 2 behavior. VC is reduced to ethene, which may be further reduced to ethane or methane. The following sequence of reactions occur in this type of plume:



This sequence has been investigated by Freedman and Gossett (1989). In this type of plume, VC degrades more slowly than TCE, and thus tends to accumulate.

4.2.4 Abiotic Degradation of Chlorinated Solvents

Chlorinated solvents dissolved in groundwater may also be degraded by abiotic mechanisms, although the reactions may not be complete and often result in the formation of a toxic intermediate. The most common abiotic reactions affecting chlorinated solvents are hydrolysis and dehydrohalogenation. Hydrolysis is a substitution reaction in which a halogen substituent is replaced with a hydroxyl (OH) group from a water molecule. Dehydrohalogenation is an elimination reaction in which a halogen is removed from a carbon atom, followed by removal of a hydrogen atom from an adjacent carbon atom, with a double bond between the carbon atoms being produced. Other possible reactions include oxidation and reduction, although Butler and Barker (1996) note that no abiotic oxidation reactions involving common halogenated solvents have been reported in the literature. They also note that reduction reactions are most commonly microbially mediated.

Hydrolysis of chlorinated methanes and ethanes has been well-demonstrated in the literature (e.g., Vogel *et al.*, 1987; Jeffers *et al.*, 1989; Vogel, 1994; Butler and Barker, 1996). The likelihood that a solvent will hydrolyze is partly dependent upon the number of halogen substituents, typically with fewer halogens resulting in more rapid hydrolysis. Dehydrohalogenation, on the other hand, is more likely to take place as the number of halogen substituents increases. One common solvent for which abiotic degradation reactions have been well-documented is 1,1,1-TCA. 1,1,1-TCA may be transformed through a series of abiotic processes (including hydrolysis) to acetic acid. Vogel and McCarty (1987) demonstrated that 1,1,1-TCA can also dehydrohalogenate to 1,1-DCE, and Jeffers *et al.* (1989) demonstrated that 1,1,2-TCA also reacts in the same manner to form 1,1-DCE. Also, once TCA is reductively dehalogenated to chloroethane (CA), it can

then hydrolyze to ethanol (Vogel and McCarty, 1987) or dehydrohalogenate to VC (Jeffers *et al.*, 1989).

Butler and Barker (1996) note that attributing changes in the presence, absence, or concentration of halogenated solvents to abiotic processes is usually difficult, particularly on the field scale. Solvents may undergo both biotic and abiotic degradation, and discerning the effects of each mechanism (on the field scale), if possible, would be very difficult. Also, as Butler and Barker (1996) note, the breakdown products of some reactions such as hydrolysis (e.g., acids and alcohols) may be more easily degraded (biotically or abiotically); these products also require additional analyses that may not be feasible for a field investigation. This makes collection of field evidence to demonstrate hydrolysis very difficult to collect and interpret, and Butler and Barker (1996) note that such evidence has not been successfully collected and presented. Evidence of dehydrohalogenation is also difficult to collect, although the presence of 1,1-DCE in conjunction with 1,1,1-TCA can provide a tentative indication that the process is ongoing, and strong evidence where it is known that no DCE has been released.

4.3 DISTRIBUTION OF HYDROCARBONS AND DAUGHTER PRODUCTS

The first step for evaluating the occurrence and methods of biodegradation of chlorinated hydrocarbons and fuel hydrocarbons is to look at the distribution of target compounds and the products of biodegradation of those compounds. At many sites such as LF-06, dissolved groundwater contamination consists of a mixture of compounds, some of which may be electron donors, some of which may be electron acceptors, and some of which may be either donors or acceptors. It is therefore important to evaluate the distribution of all relevant compounds and the spatial relationships between those plumes.

For example, it is useful to determine if a source of dissolved electron donors (e.g., BTEX) coincides with a plume of dissolved contaminants that are most likely to be used as electron acceptors. The donors are needed to fuel biodegradation reactions that will either use some contaminants as electron acceptors or that will produce geochemical conditions

that make the use of contaminants as electron acceptors more favorable. Also, because reductive dehalogenation is the most common biodegradation reaction involving chlorinated hydrocarbons, it is useful to look for the presence of compounds that are most likely the product of biodegradation reactions, such as *cis*-1,2-DCE or VC. These compounds are rarely released to groundwater, but are products of reductive dehalogenation. In addition, if *cis*-1,2-DCE is clearly the most common isomer of DCE, then the occurrence of reductive dehalogenation can be inferred.

The following sections present contaminant and daughter product distributions at LF-06, providing the initial evidence that dissolved fuels and chlorinated solvents are biodegrading. This evidence alone is not conclusive, but when combined with geochemical evidence presented in later sections, it is a significant indicator of biodegradation.

4.3.1 Fuel Hydrocarbons

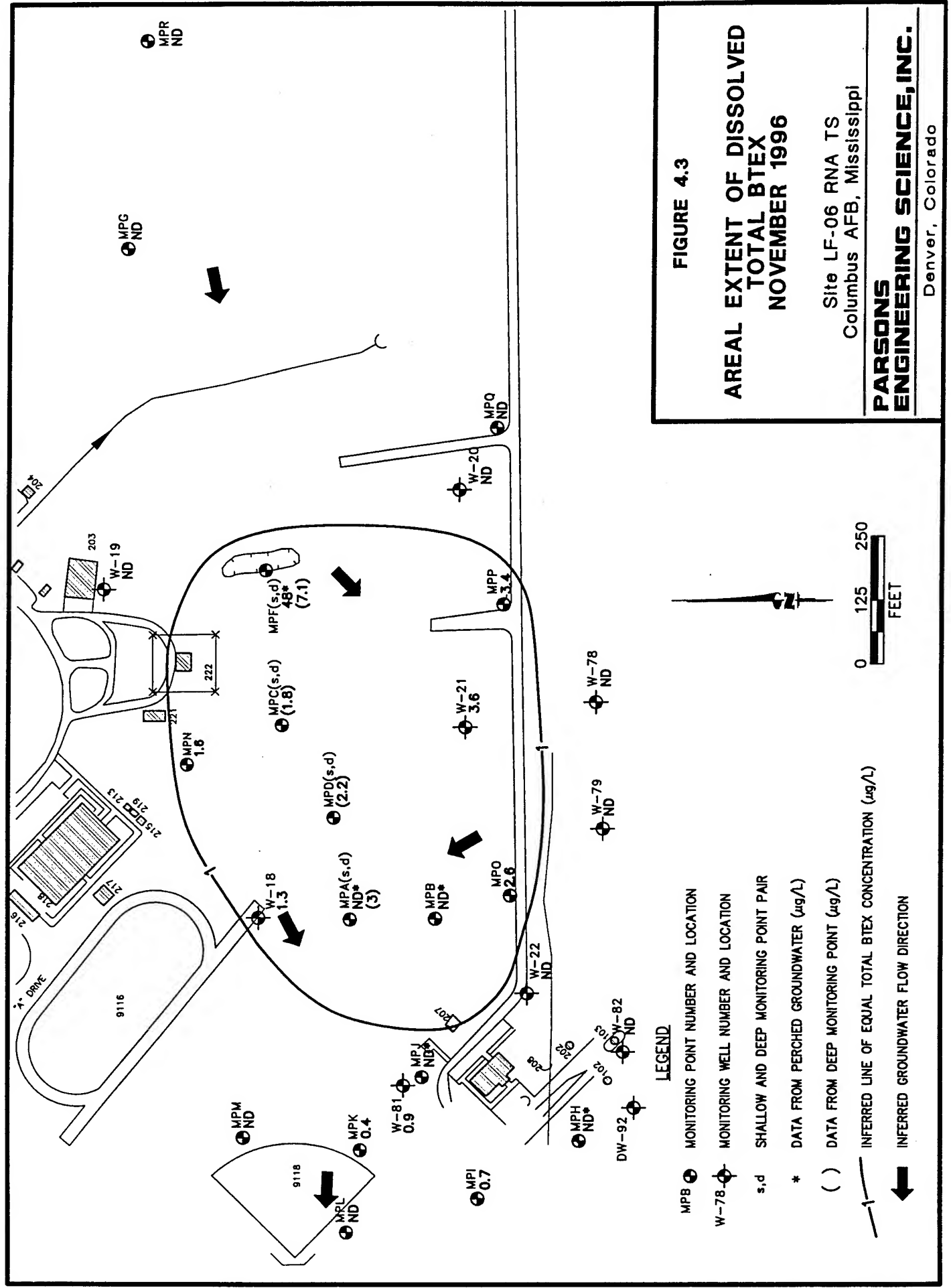
Fuel hydrocarbons detected in groundwater at LF-06 include all of the BTEX compounds, as well as trimethylbenzene (TMB) isomers, 1,2,3,4-tetramethylbenzene (TEMB), and total volatile hydrocarbons (TVH) as gasoline. Results for fuel hydrocarbon analyses performed on samples collected in November 1996 are presented in Table 4.2, and the distribution of total BTEX is shown on Figure 4.3. Where detected, total BTEX concentrations ranged from 0.4 to 48 micrograms per liter ($\mu\text{g/L}$). Detected benzene concentrations ranged from 0.4 to 12 $\mu\text{g/L}$, with concentrations exceeding the USEPA maximum contaminant level (MCL) of 5 $\mu\text{g/L}$ at only one location. At that location, MPF(s), the benzene concentration was 12 $\mu\text{g/L}$. At MPF(s), the monitoring point is screened in a perched zone above the water table. None of the detected toluene, ethylbenzene, or xylenes concentrations exceeded MCLs.

TMB isomers were detected in 6 wells/points, with concentrations ranging from 0.5 $\mu\text{g/L}$ to 10 $\mu\text{g/L}$. Except at MPB (in a perched zone), samples containing TMB

TABLE 4.2
GROUNDWATER QUALITY DATA SUMMARY
FOR BTEX, TMBs, AND TVH
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Sample ID	Date Sampled	Benzene		Toluene		Ethyl- Benzene		Total Xylenes		Total BTEX		1,2,4- TMB (µg/L)	1,2,3- TMB (µg/L)	1,2,3,4- TMB (µg/L)	TVH- Gasoline (mg/L ^{b/})
		(µg/L ^{a/})	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L ^{b/})
W18	11/15/96	1.3	ND ^{d/}	ND ^{d/}	ND	ND	ND	ND	1.3	ND	ND	ND	ND	ND	ND
W19	11/17/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W20	11/14/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W21	11/14/96	3.6	ND	ND	ND	ND	ND	ND	3.6	ND	ND	ND	ND	0.5	ND
W22	11/13/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W1 ^{d/}	11/13/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W78	11/14/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W2 ^{d/}	11/14/96	NA ^{d/}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
W79	11/15/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W81	11/13/96	0.9	ND	ND	ND	ND	ND	ND	0.9	ND	ND	ND	ND	1.3	ND
W82	11/15/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPA(s)	11/17/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.2	ND
MPA(d)	11/17/96	3.0	ND	ND	ND	ND	ND	ND	3	ND	ND	ND	ND	0.9	ND
MPB	11/18/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.6	ND
MPC(s)	11/17/96	1.8	ND	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND	ND	ND
MPC(d)	11/17/96	1.8	ND	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND	ND	ND
MPD(d)	11/17/96	2.2	ND	ND	ND	ND	ND	ND	2.2	ND	ND	ND	ND	1.7	ND
MPF(s)	11/18/96	12	ND	ND	ND	ND	ND	ND	48	ND	ND	ND	ND	5.1	0.6
MPV ^{d/}	11/18/96	12	ND	ND	ND	ND	ND	ND	47	ND	ND	ND	ND	5.0	0.6
MPF(d)	11/17/96	2.1	3.2	ND	ND	0.5	1.3	ND	7.1	ND	ND	ND	ND	ND	ND
MPG	11/18/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPH	11/15/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPI	11/15/96	0.7	ND	ND	ND	ND	ND	ND	0.7	ND	ND	ND	ND	ND	ND
MPJ	11/17/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPK	11/15/96	0.4	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND
MPL	11/15/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W3 ^{d/}	11/18/96	15	1.2	ND	ND	2.7	3.5	ND	22.4	ND	ND	0.4	8.4	27	0.3
MPM	11/13/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPN	11/17/96	1.6	ND	ND	ND	ND	ND	ND	1.6	ND	ND	ND	ND	ND	ND
MPO	11/14/96	2.0	ND	ND	ND	ND	0.6	ND	2.6	ND	ND	0.6	ND	ND	ND
MPP	11/14/96	3.4	ND	ND	ND	ND	ND	ND	3.4	ND	ND	ND	ND	ND	ND
MPQ	11/14/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPR	11/17/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

^{a/} µg/L = micrograms per liter.
^{b/} mg/L = milligrams per liter.
^{c/} ND = Analyte not detected.
^{d/} W1 is a duplicate sample of W22.
^{e/} W2 is a duplicate sample of W78.
^{f/} NA = Not analyzed.
^{g/} MPV is a duplicate sample of MPF(S).
^{h/} W3 is a duplicate sample of MPL.



compounds also contained BTEX. 1,2,3,4-TEMB was detected in samples from 7 wells and points, with concentrations ranging from 0.5 µg/L to 5.7 µg/L. In general, TEMB was detected in wells in which BTEX were detected, but at 2 points [MPA(s) and MPB], TEMB was detected but BTEX were not. Both of these points are screened in perched zones. TVH were detected at one location. At MPF(s), the TVH concentration was 0.6 milligrams per liter (mg/L).

The fuel hydrocarbon data do not provide a clear indication of the source of contamination, but do suggest some possible source areas. The strongest indication of a source area is provided by the BTEX concentrations detected in MPF(s). That point was installed at the edge of a former disposal trench (see Figures 2.1 and 3.3, and the boring logs in Appendix A). Given the observed groundwater flow direction (roughly east to west), a source may also be present in the vicinity of MPP and W-21.

4.3.2 Chlorinated Ethenes

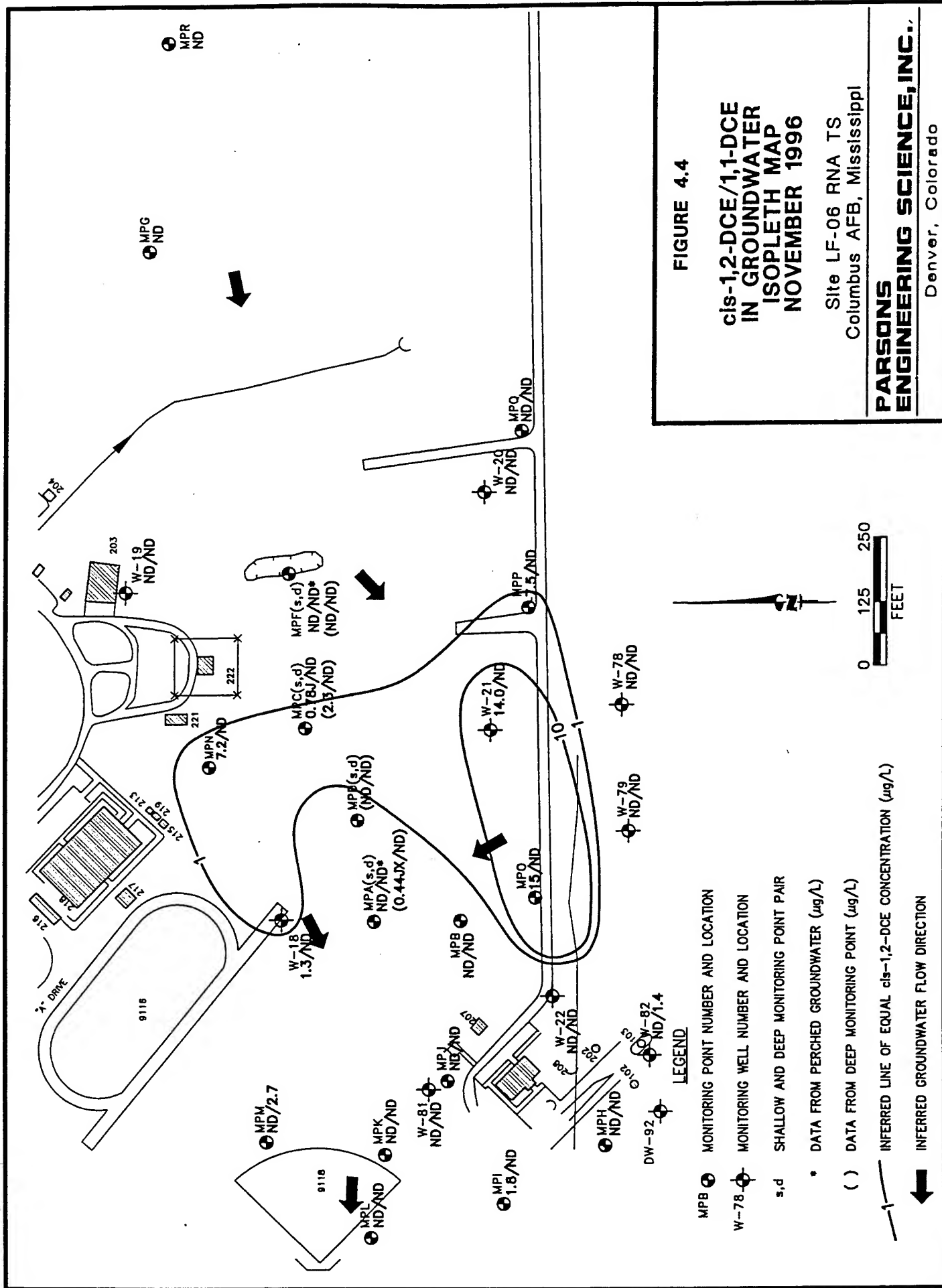
Chlorinated ethenes detected in groundwater at LF-06 include TCE, DCE, and VC. Data for chlorinated ethenes and other chlorinated compounds are presented in Table 4.3. Distributions of *cis*-1,2-DCE and 1,1-DCE are shown on Figure 4.4; the VC distribution is presented on Figure 4.5. TCE is not shown because it was detected in only 3 wells, and PCE was not detected in any samples.

As measured in November 1996, TCE concentrations detected in groundwater ranged from 0.68J µg/L at MPO to 7.4 µg/L at W-21 and 1.1 µg/L at MPM. Of these detections, the only one exceeding the MCL of 5 µg/L was the 7.4 µg/L detected at W-21. The detection of TCE at W-21 suggests that there may be a source of TCE associated with the apparent source of fuel hydrocarbons in that area. MPO is downgradient of W-21, so the detection of TCE at that point is likely related to the same source as the TCE detected at W21. The source of TCE at MPM is not clear, although other chlorinated compounds have been detected there (although BTEX have not).

TABLE 4.3
GROUNDWATER QUALITY DATA SUMMARY
FOR CHLORINATED VOCs
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Sample ID	Date Sampled	Vinyl Chloride (µg/L) ^a	Chloro-ethane (µg/L)	1,1-DCE (µg/L)	Dichloro-methane (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCA (µg/L)	cis-1,2-DCE (µg/L)	1,1,1-TCA (µg/L)	TCE (µg/L)	Chloro-benzene (µg/L)	1,3-DCB (µg/L)	1,2-DCB (µg/L)
W18	11/15/96	4.9	ND ^b	ND	ND	ND	ND	1.3	ND	ND	13	ND	0.78 J ^c
W19	11/17/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W20	11/14/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W21	11/14/96	10	ND	ND	0.43 J	ND	0.81 J	14.0	ND	7.4	13	ND	1.9
W22	11/13/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W1 ^d	11/13/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W78	11/14/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W2 ^d	11/14/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W79	11/15/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
W81	11/13/96	4.8	ND	ND	ND	ND	ND	ND	ND	ND	6.5	ND	0.49 J
W82	11/15/96	ND	ND	1.4	ND	ND	ND	ND	0.73 J	ND	ND	ND	ND
MPA(S)	11/17/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPA(D)	11/17/96	6.6	ND	ND	ND	ND	1.2	0.44 J X ^e	ND	ND	20	ND	0.88 J
MPB	11/18/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPC(S)	11/17/96	2.0 J ^d	1.3 J	ND	ND	ND	1.2	0.78 J	ND	ND	14	ND	0.87 J
MPC(D)	11/17/96	3.0	ND	ND	ND	ND	ND	2.3	ND	ND	2.3	ND	ND
MPD(D)	11/17/96	4.2	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	0.8 J
MPF(S)	11/18/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	200 E ^f	ND	ND
MPV ^g	11/18/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	190 E	4.5	5.2
MPF(D)	11/17/96	1.7 J	ND	ND	ND	ND	ND	ND	ND	ND	6.1	ND	ND
MPG	11/18/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPH	11/15/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPI	11/15/96	3.4	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND	ND
MPJ	11/17/96	2.1 J	2.1 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPK	11/15/96	3.0	ND	ND	ND	ND	ND	ND	ND	ND	6.1	ND	0.55 J
MPL	11/15/96	2.1 J	ND	ND	ND	ND	ND	ND	ND	ND	3.7	ND	ND
W3 ^h	11/18/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPM	11/13/96	ND	ND	2.7	ND	ND	ND	ND	3.8	1.1	ND	ND	ND
MPN	11/17/96	2.4 J	ND	ND	ND	ND	ND	7.2	ND	ND	23	ND	11
MPO	11/14/96	8.0	ND	ND	1.0	ND	0.44 J	15.0	ND	0.68 J	1.6 J	ND	ND
MPP	11/14/96	9.0	ND	ND	0.49 J	ND	ND	7.5	ND	ND	2.3	ND	0.74 J
MPQ	11/14/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPR	11/17/96	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

^a µg/L = micrograms per liter.
^b ND = Analyte not detected.
^c J = Estimated value.
^d W1 is a duplicate sample of W22.
^e W2 is a duplicate sample of W78.
^f X = Not confirmed by mass spectrometer.
^g E = Extrapolated value.
^h MPV is a duplicate sample of MPF(S).
ⁱ W3 is a duplicate sample of MPL.



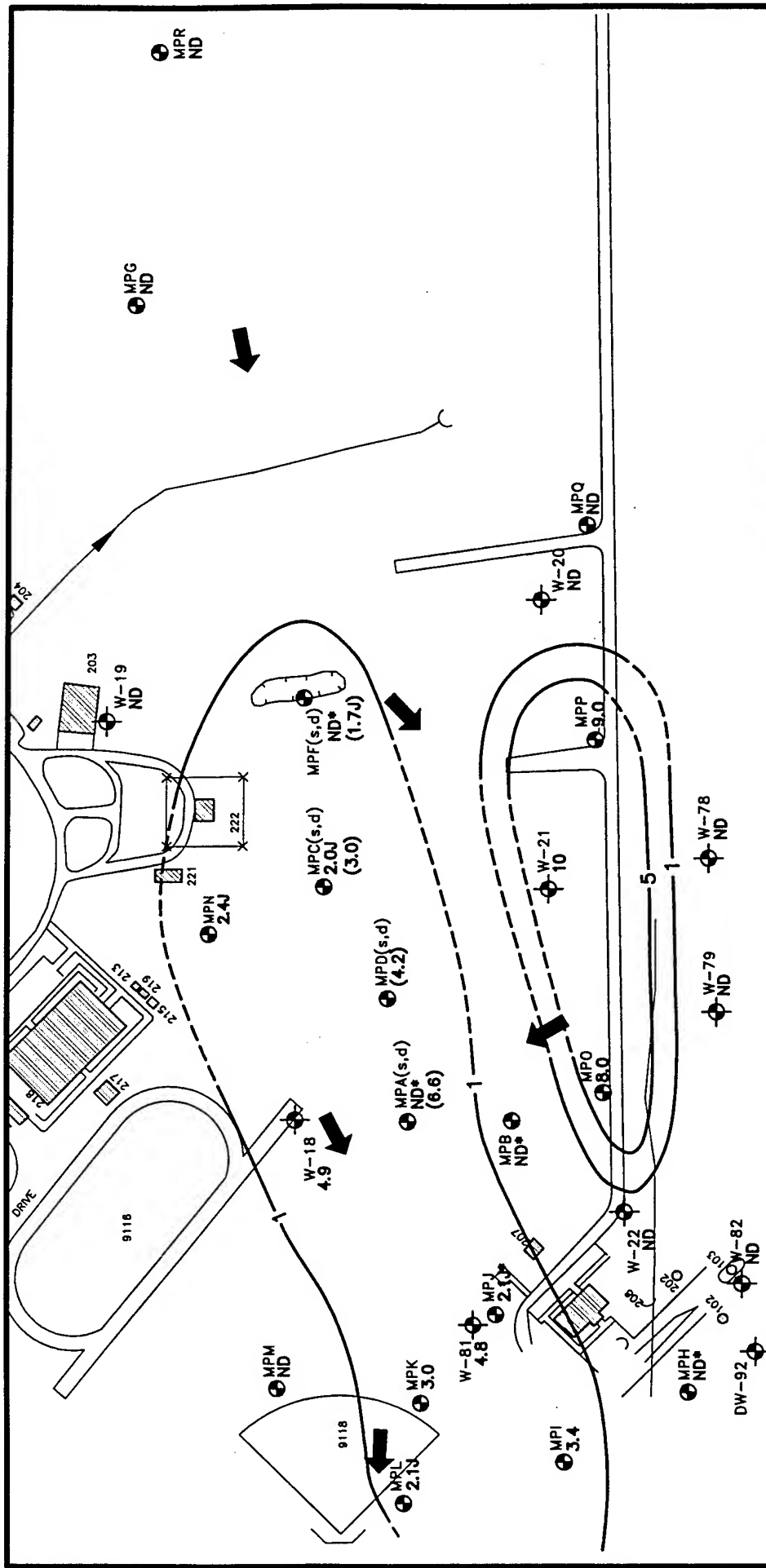
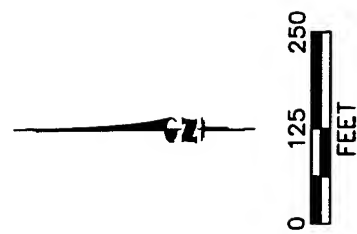


FIGURE 4.5

VINYL CHLORIDE IN GROUNDWATER ISOPLETH MAP NOVEMBER 1996

Site LF-06 RNA TS
Columbus AFB, Mississippi

**PARSONS
ENGINEERING SCIENCE, INC.**
Denver, Colorado



LEGEND

- MPB ● MONITORING POINT NUMBER AND LOCATION
- W-78 ● MONITORING WELL NUMBER AND LOCATION
- s,d SHALLOW AND DEEP MONITORING POINT PAIR
- * DATA FROM PERCHED GROUNDWATER (g/L)
- () DATA FROM DEEP MONITORING POINT (μg/L)
- LINE OF EQUAL VINYL CHLORIDE CONCENTRATION (μg/L) (DASHED WHERE INFERRED)
- INFERRED GROUNDWATER FLOW DIRECTION

cis-1,2-DCE was detected at several wells (Figure 4.4), but the highest detected concentration was 15 µg/L at MPO. This does not exceed the MCL of 70 µg/L. The two locations with the highest concentrations of *cis*-1,2-DCE coincide with the TCE detections at W-21 and MPO, and the third highest concentration (7.5 µg/L) was detected at MPP (near the suspected W-21 source area). A concentration of 1.8 µg/L was also detected well downgradient of MPO, at MPI. In addition, another apparent plume of *cis*-1,2-DCE was detected in MPN and downgradient at W-18. The concentration at MPN was 7.2 µg/L, while the concentration at W-18 was 1.3 µg/L, suggesting that a source area may be present in the vicinity of MPN. Also, concentrations of 0.78J and 2.3 µg/L were detected in MPC(s) and MPC(d), respectively; these wells are downgradient of the possible source area near MPF.

At all wells/points sampled, no *trans*-1,2-DCE was detected. This trend is what would be expected if TCE is being degraded to DCE via reductive dehalogenation. As noted before, under the influence of biodegradation, *cis*-1,2-DCE is a more common daughter product than the other DCE isomers. Furthermore, the *trans* isomer is more common when DCE is used for commercial applications. The presence of *cis*-1,2-DCE is therefore a good indicator that the initial step of reductive dehalogenation of TCE is taking place in groundwater at LF-06.

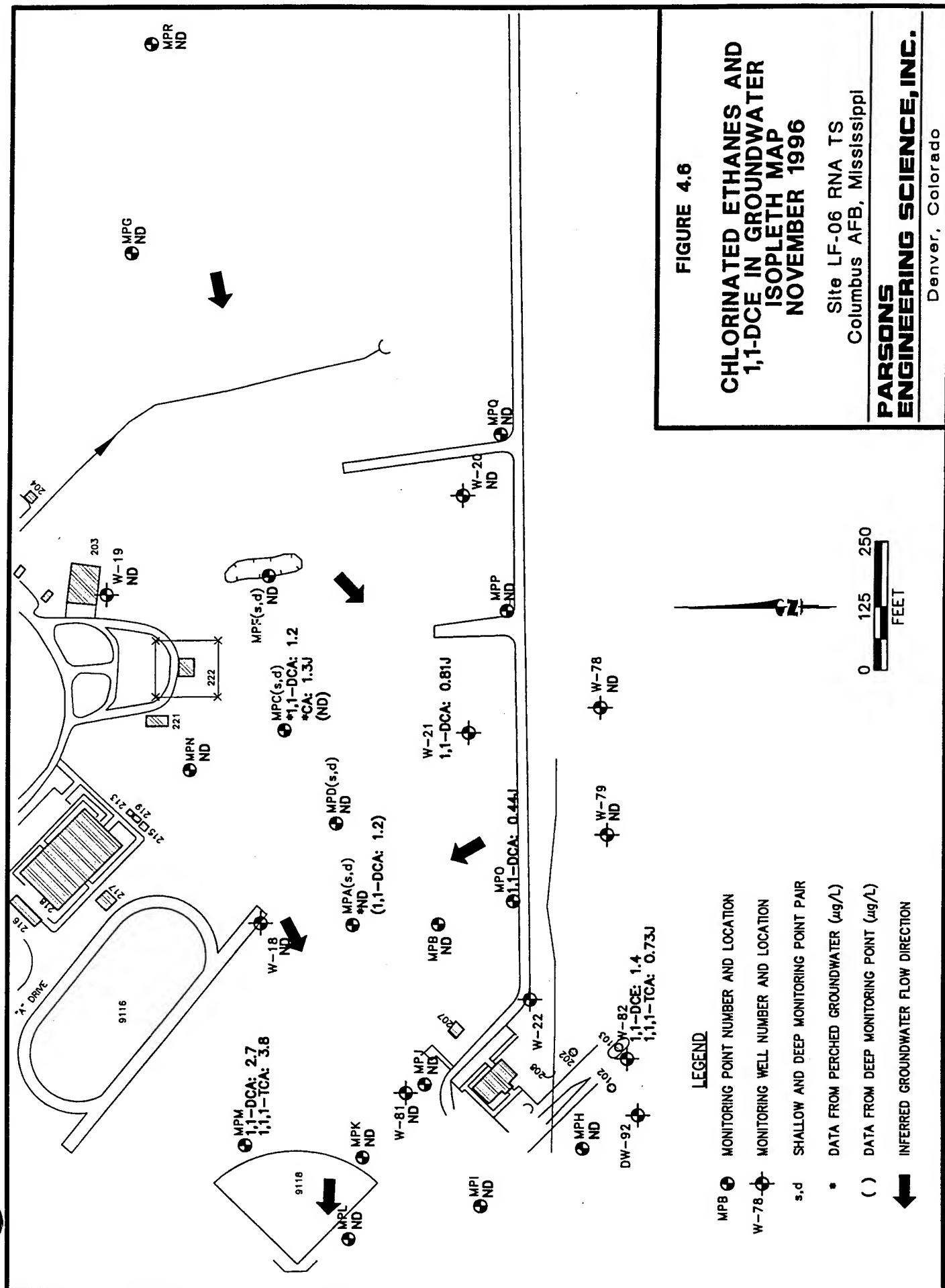
1,1-DCE was detected in samples from 2 wells at LF-06. Concentrations of 1.4 µg/L and 2.7 µg/L were detected in samples from W-82 and MPM, respectively (Figure 4.4). These concentrations do not exceed the MCL of 7 µg/L. Neither TCE nor any other isomer of DCE were detected in these wells. This suggests that while 1,1-DCE could have been produced by reductive dehalogenation of TCE, it is more likely it came from another source. However, as will be discussed in Section 4.3.4, 1,1,1-TCA was also detected in both of these wells. This suggests that 1,1-DCE may be produced abiotically via dehydrohalogenation of 1,1,1-TCA.

The distribution of VC in site groundwater is shown on Figure 4.5. The 15 VC concentrations detected at the site range from 1.7J to 10 µg/L (Table 4.3). Generally, where detected, VC concentrations exceeded the MCL of 2 µg/L. The VC plumes appear to emanate from similar sources as those indicated by the BTEX, TCE, and DCE data, and the extents of the VC plumes are also similar to those indicated by the other contaminant data. In fact, VC was detected at all 9 locations where *cis*-1,2-DCE was detected. The presence of VC in groundwater is also a good indicator of the occurrence of reductive dehalogenation, because VC is typically a gas at most working temperatures [the boiling point of VC is about 13.5°C/7°F (Montgomery, 1996)]. Because of this, VC is not commonly used as a solvent, and is instead used for plastic manufacturing. In addition, the low boiling point indicates that when liquid VC is spilled, most of the mass is likely to volatilize before reaching groundwater unless there is a large-volume release.

4.3.3 Chlorinated Ethanes

Chlorinated ethanes detected in groundwater at LF-06 include 1,1,1-TCA, 1,1-DCA, and CA (Table 4.3). The distribution of these compounds is shown on Figure 4.6. Relatively low concentrations of these compounds were detected, with the maximum concentration being 3.8 µg/L of 1,1,1-TCA at MPM. 1,1,1-TCA and 1,1-DCA concentrations did not exceed their respective MCLs of 200 µg/L and 3,500 µg/L. In general, chlorinated ethanes were detected in the same wells as the chlorinated ethenes.

1,1,1-TCA was detected in only two wells/points (W-82 and MPM). As discussed in section 4.3.3, these are the only wells in which 1,1-DCE was detected. This suggests that 1,1,1-TCA is being dehydrohalogenated to 1,1-DCE in those locations. Also, the absence of 1,1,1-TCA and the presence of 1,1-DCA and CA in other wells that also contained BTEX and chlorinated ethenes suggests that reductive dechlorination is ongoing within the area of the BTEX plume. Additionally, 1,1-DCA is not commonly used as a solvent, whereas 1,2-DCA is; therefore, the presence of 1,1-DCA rather than 1,2-DCA further suggests that reductive dechlorination of 1,1,1-TCA is ongoing in the central portion of the



LF-06 contaminant plumes. Reductive dehalogenation could account for the absence of 1,1,1-TCA in the central plume area, while in the periphery wells (where conditions are likely less reducing), TCA is not reductively dechlorinated but instead reacts abiotically to form 1,1-DCE. The abiotic reaction is relatively slow compared to reductive dehalogenation, which could explain why some 1,1,1-TCA remains in the groundwater at the plume periphery.

4.3.4 Chlorobenzenes

Chlorobenzenes detected in groundwater at LF-06 include 1,2-DCB, 1,3-DCB, and CB (Table 4.3). These compounds generally were detected in the same wells as the other contaminants, and a CB plume appears to be originating from the vicinity of MPF(s) and migrating to the west (Figure 4.7). Detected CB concentrations ranged from 1.6J $\mu\text{g/L}$ to 200E $\mu\text{g/L}$, with all but one concentration in the range of 1.6J to 23 $\mu\text{g/L}$. The highest CB concentration (200 $\mu\text{g/L}$) was detected in MPF(s), and this is the only one of the chlorobenzene compounds present in a concentration exceeding MCLs. The MCL for CB is 100 $\mu\text{g/L}$, and the MCL for both 1,2-DCB and 1,3-DCB is 600 $\mu\text{g/L}$. Of the DCBs, 1,2-DCB is the most commonly detected; 1,3-DCB was detected only in MPF(s), at a concentration of 4.2 $\mu\text{g/L}$. 1,2-DCB was detected only in wells that also contained CB, and 1,2-DCB concentrations ranged from 0.49J $\mu\text{g/L}$ to 11 $\mu\text{g/L}$.

It is possible that some DCB is being reductively dechlorinated to CB in the center of the plume area where conditions may be the most reducing. However, it is more likely that both CB and DCB are being utilized aerobically as electron donors/substrates in the same manner as the BTEX compounds. This activity is most likely taking place at the plume fringes where aerobic conditions are prevalent, but may also take place throughout the plume when precipitation events briefly introduce oxygenated recharge to the water table.



4.3.5 Other Chlorinated Compounds

One other chlorinated compound was detected in groundwater at LF-06. Dichloromethane (DCM, also known as methylene chloride) was detected at concentrations of 0.43J $\mu\text{g/L}$ in W-21, 1.0 $\mu\text{g/L}$ in MPO, and 0.49J $\mu\text{g/L}$ in MPP. These points are all along the southern boundary of the landfill area, and these detections may be indicative of a source of DCM in the vicinity of MPP. The detected concentrations do not exceed the MCL of 5 $\mu\text{g/L}$.

DCM is used as a solvent, and is also an ingredient in paints and varnishes (Montgomery, 1996). It is commonly used as a laboratory solvent and is often present in samples due to laboratory contamination, and this might explain detections of DCM in site groundwater. However, given that the three wells/points in which DCM was detected lie roughly along a flowpath and coincide with locations where other chlorinated solvents were detected, it seems more likely that DCM is present in site groundwater due to a source in the vicinity of MPP and W-21.

4.3.6 Chloride

Chloride ions are removed from chlorinated solvents and enter solution during biodegradation, whether via reductive dehalogenation or aerobic oxidation. Therefore, chloride concentrations in groundwater should increase above background levels in areas where reductive dehalogenation or aerobic biodegradation are taking place. Chloride concentrations are presented in Table 4.4, and Figure 4.8 shows the distribution of chloride in shallow groundwater at the site. Background chloride concentrations (measured in wells without contamination in shallow site groundwater range from about 2.9 mg/L to about 20 mg/L, with one concentration (at MPR) of 322.5 mg/L. It is not clear what is responsible for this anomalous concentration. Most background chloride concentrations are less than 8.7 mg/L. Chloride concentrations within the boundaries of the chlorinated solvent plumes generally are elevated slightly above background, with a maximum concentration of 182.5

TABLE 4.4
GROUNDWATER ELECTRON ACCEPTORS/BYPRODUCTS
ANALYTICAL DATA
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Sample ID	Date Sampled	Dissolved Oxygen (mg/L) ^a	Carbon Dioxide (mg/L)	Lab Chloride (mg/L)	Field Chloride (mg/L)	Lab Sulfate (mg/L)	Field Sulfate (mg/L)	Lab NO ₂ ⁻ (mg/L)	Field NO ₂ ⁻ (mg/L)	Lab NO ₃ ⁻ (mg/L)	Field NO ₃ ⁻ (mg/L)	Ferrous Iron (mg/L)	Mn ²⁺ (mg/L)	NH ₄ ⁺ (mg/L)	Methane (mg/L)
W18	11/15/96	0.16	250	16.8	21	8.9	16.11	ND ^b	ND	ND	0.2	4.77	1.7	2	0.11
W19	11/17/96	2.48	130	2.3	2.9	11.0	15.03	ND	0.003	0.81	1.0	0.01	ND	ND	ND
W20	11/14/96	0.64	90	6.7	7.9	0.41	0.49	ND	0.001	2.5	2.0	ND	0.1	ND	ND
W21	11/14/96	0.17	400	54.1	58	ND	1.46	ND	0.017	0.38	0.5	0.01	0.1	ND	2.7
W22	11/13/96	0.56	130	3.8	4.8	11.0	13.73	ND	0.004	ND	0.7	0.02	0.3	ND	ND
W1 ^c	11/13/96	NA	NA	3.7	NA	11.6	NA	ND	NA	ND	NA	NA	NA	NA	ND
W78	11/14/96	0.29	180	17.5	19.5	50.6	48.97	ND	0.002	ND	0.4	0.35	ND	ND	0.021
W79	11/15/96	2.88	90	3.7	5.0	1.3	1.19	ND	0.002	1.4	1.2	0.01	ND	ND	ND
W81	11/13/96	0.20	500	14.4	22.5	3.8	12.43	ND	ND	ND	ND	4.87	1.0	>10	0.70
W82	11/15/96	2.03	160	5.5	6.5	1.5	2.22	ND	0.001	1.9	2.2	0.01	0.1	ND	ND
MPA(s)	11/17/96	0.62	250	4.2	5.3	119	130.55	ND	0.001	ND	0.4	22.75	0.8	4	0.85
MPA(d)	11/17/96	0.96	350	18.4	18.8	1.3	2.12	ND	0.002	ND	0.4	1.29	0.8	ND	0.31
MPB	11/18/96	1.12	250	2.8	3.2	48.9	51.7	ND	0.019	3.2	1.3	1.77	0.4	1	4.7
MPC(s)	11/17/96	1.94	350	13.2	17.8	4.0	4.22	ND	ND	ND	0.5	75.0	2.0	>10	1.9
MPC(d)	11/17/96	0.63	350	36.6	46	ND	1.41	ND	0.002	0.39	0.5	0.96	1.3	ND	0.35
MPD(d)	11/17/96	0.15	300	7.2	8	4.8	1.68	ND	0.002	ND	0.2	0.62	0.8	ND	0.24
MPF(s)	11/18/96	0.22	500	6.4	8.5	13.4	6.51	ND	ND	ND	3.5	22.15	0.7	>10	6.5
MPF(d)	11/17/96	0.45	400	22.4	27.5	1.0	6.32	ND	ND	ND	0.5	95.5	14.4	>10	0.44
MPG	11/18/96	NA	40	3.3	8.6	8.8	19.48	ND	0.001	ND	ND	2.94	ND	0.1	ND
MPH	11/15/96	5.09	100	3.9	6.5	14.9	15.78	ND	0.001	0.61	1.0	5.45	ND	0.8	ND
MPI	11/15/96	0.20	250	51.2	10.9	1.4	1.68	ND	ND	ND	0.2	2.10	0.1	ND	0.26
MPJ	11/17/96	2.82	150	23.4	26	0.36	1.51	ND	0.002	ND	0.7	7.0	ND	0.1	0.017
MPK	11/15/96	0.18	500	18.9	27.5	3.7	2.87	ND	0.001	ND	0.8	71.75	5.4	>10	0.22
MPL	11/15/96	0.28	250	11.3	12.8	5.6	2.43	ND	ND	ND	6.7	6.40	9.1	1	0.21
MPM	11/13/96	4.88	50	6.5	9.6	0.27	1.73	ND	ND	1.3	1.5	2.01	0.1	0.3	ND
MPN	11/17/96	0.32	500	23.1	132.5	2.3	3.95	ND	ND	ND	0.4	94.25	7.4	>10	0.059
MPO	11/14/96	0.26	300	177.0	182.5	6.0	2.97	ND	ND	0.35	0.8	0.71	ND	ND	1.8
MPP	11/14/96	0.27	300	44.2	8.7	2.2	0.59	ND	0.001	0.073	0.1	2.10	ND	ND	2.7
MPQ	11/14/96	4.78	50	70.7	78.0	0.34	3.14	ND	0.001	1.5	1.1	3.16	ND	ND	ND
MPR	11/17/96	0.18	160	271.0	322.5	0.88	1.68	ND	ND	0.3	0.8	6.55	1.1	1	0.012

^a mg/L = milligrams per liter.

^b ND = Analyte not detected.

^c Duplicate sample of W22.

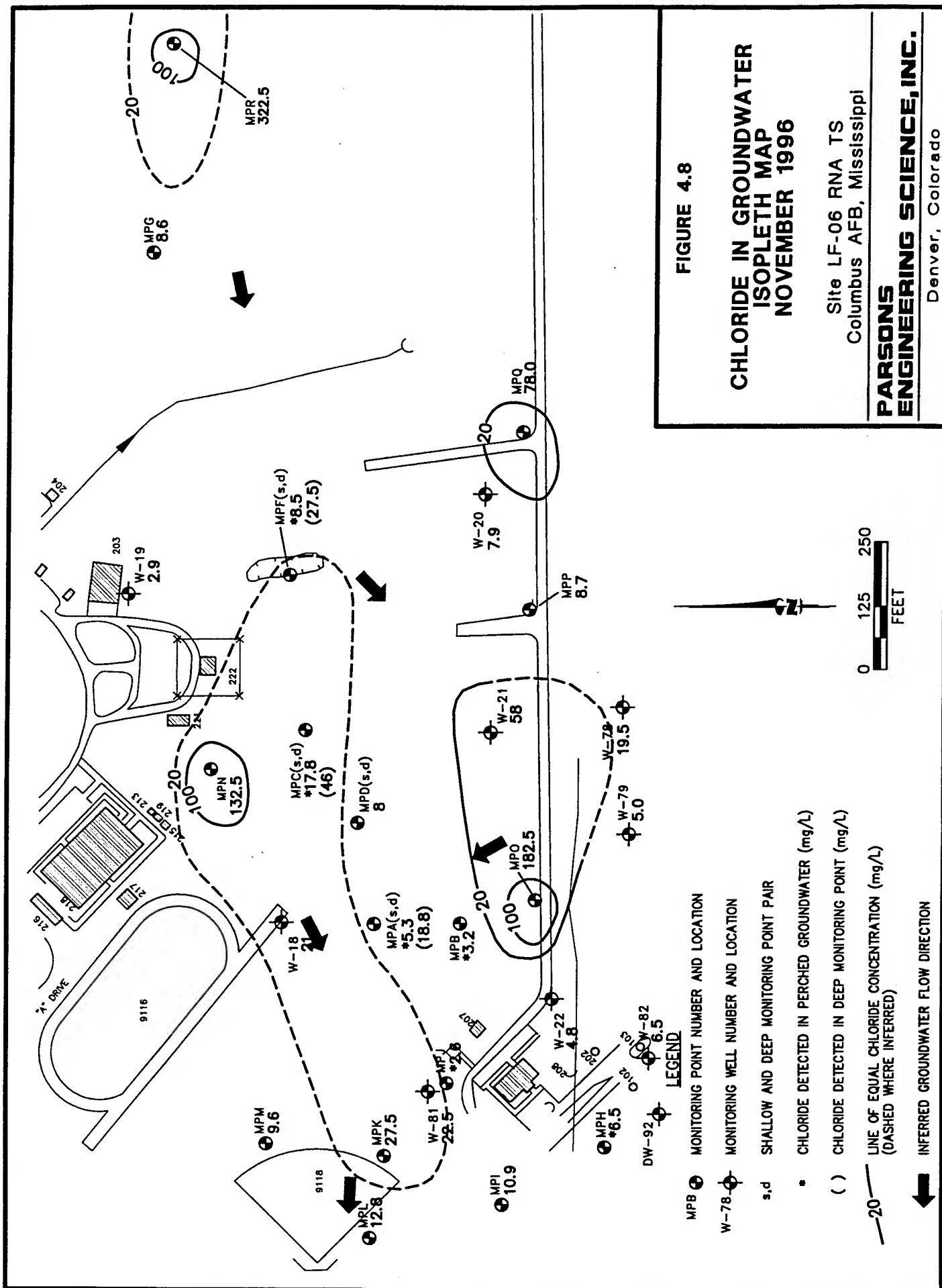


FIGURE 4.8

**CHLORIDE IN GROUNDWATER
ISOPLETH MAP
NOVEMBER 1996**

Site LF-06 RNA TS
Columbus AFB, Mississippi

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

mg/L. Most chloride concentrations within the areas where biodegradation is indicated by chemical and geochemical data are greater than 20 mg/L.

In conjunction with the distributions of CAHs shown on Figures 4.4 through 4.6, the elevated chloride concentrations observed at LF-06 are a good indication that CAHs are undergoing microbially mediated degradation. Given the presence of daughter products such as *cis*-1,2-DCE, VC, 1,1-DCA, and CA, it is likely that some of the chloride is a product of reductive dehalogenation. However, because chloride is also released during consumption of solvents as substrates, some of the chloride plume may be related to these reactions. It is also possible that landfill materials may also be contributing chloride to the groundwater. However, the presence of daughter products strongly suggests that some of the chloride is indeed derived from solvent biodegradation.

4.4 ADDITIONAL EVIDENCE OF BIODEGRADATION

In addition to the distribution of contaminants and daughter products, other evidence can be used to support the interpretation that biodegradation of fuel hydrocarbons and chlorinated solvents is ongoing at LF-06. As noted in Section 4.2, comparing concentrations and distributions of electron donors, electron acceptors, and byproducts of microbially mediated reactions can help indicate what types of processes are operating at a site. In addition, other geochemical parameters, including redox potential, alkalinity, and other changes in groundwater chemistry can also provide supporting evidence. Other data, such as volatile fatty acid concentrations, also can be useful for interpreting and confirming biodegradation mechanisms.

4.4.1 Electron Donors, Native Electron Acceptors, and Byproducts

When investigating the biodegradation of hydrocarbons, it is also necessary to look at the distribution of other compounds that are used in the microbially mediated reactions that facilitate contaminant degradation. The distribution of other potential electron donors (besides contaminants), such as dissolved organic carbon (native or from leachate), is useful for evaluating the feasibility of reductive dehalogenation or cometabolism (i.e.,

biodegradation reactions involving another substrate). Moreover, electron acceptor and metabolic byproduct data will further indicate what processes may be facilitating contaminant degradation.

4.4.1.1 Organic Carbon in Groundwater

Dissolved organic carbon also can act as a source of electron donors during the reductive dehalogenation of CAHs. Dissolved TOC concentrations can be used as an indicator of the presence of such native carbon compounds in wells outside of the area containing dissolved contamination (anthropogenic organic compounds, such as CAHs, petroleum hydrocarbons, or landfill leachate also are measured by the TOC analytical method).

TOC dissolved in groundwater was measured in some of the groundwater samples collected in November 1996. These concentrations are presented in Table 4.5. Dissolved TOC concentrations detected in shallow groundwater at LF-06 range from 2.1 mg/L to 34.7 mg/L. The highest concentration was measured in MPO and may reflect the presence of contamination, including landfill leachate. Elsewhere, the TOC concentrations did not exceed 5.6 mg/L. Most of these other concentrations were measured in wells/points that are near the fringes of the contaminant plumes and thus are likely to represent background concentrations.

These background concentrations of dissolved TOC are noteworthy because they represent additional organic matter that is available for use as a substrate in biodegradation reactions. The background concentrations likely represent compounds dissolved from dispersed organic matter throughout the aquifer, and possibly some landfill leachate. In addition to the soil TOC, this carbon source should provide a continuing source of electron donors to be used in microbial redox reactions. As discussed in Section 4.4.1.2, other

TABLE 4.5
GROUNDWATER GEOCHEMICAL INDICATORS
ANALYTICAL DATA
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Sample ID	Date Sampled	Temp (°C)	pH	Conductivity (μS/cm ^a)	Total Field Alkalinity (mg/L ^b)	Total Laboratory Alkalinity (mg/L)	Total Redox Potential (mV ^c)	TOC (mg/L)
W18	11/15/96	19.3	5.6	245	68	NA ^d	100	NA
W19	11/17/96	19.6	5.2	85	21	NA	284	NA
W20	11/14/96	17.6	4.5	63	3	< 5	254	NA
W21	11/14/96	16.9	4.3	240	0	< 5	216	4.6
W22	11/13/96	20.2	4.6	62	0	< 5	175	NA
W1 ^e	11/13/96	NA	NA	NA	NA	< 5	NA	NA
W78	11/14/96	18.7	4.5	198	4	< 5	184	2.1
W79	11/15/96	16.9	4.7	44	7	NA	181	NA
W81	11/13/96	20.0	6.2	624	322	298	-65	NA
W82	11/15/96	20.8	4.4	58	6	NA	233	NA
MPA(s)	11/17/96	20.3	6.8	824	290	NA	-103	NA
MPA(d)	11/17/96	20.1	5.7	118	5	NA	-68	NA
MPB	11/18/96	19.8	5.0	493	352	NA	1	NA
MPC(s)	11/17/96	17.1	6.5	491	230	NA	-44	NA
MPC(d)	11/17/96	17.8	5.4	177	15	NA	-300	NA
MPD(d)	11/17/96	18.0	5.0	115	35	NA	96	NA
MPF(s)	11/18/96	17.5	6.3	820	425	NA	-122	NA
MPF(d)	11/17/96	18.4	6.5	620	255	NA	-15	NA
MPG	11/18/96	17.8	6.5	85	18	NA	-71	NA
MPH	11/15/96	18.3	5.4	78	10	NA	75	NA
MPI	11/15/96	20.8	5.1	230	11	NA	114	ND ^f
MPJ	11/17/96	19.9	5.7	129	13	NA	-60	NA
MPK	11/15/96	20.5	6.2	504	215	NA	-1	5.6
MPL	11/15/96	20.5	5.7	268	97	NA	46	NA
MPM	11/13/96	18.7	5.4	62	6	7.1	660	NA
MPN	11/17/96	18.3	6.8	599	245	NA	-55	NA
MPO	11/14/96	18.8	4.8	634	19	19.5	87	34.7
MPP	11/14/96	18.8	4.7	208	10	10	67	3.4
MPQ	11/14/96	17.5	6.0	410	19	21.1	158	NA
MPR	11/17/96	19.2	4.9	750	6	NA	56	NA

^a μS/cm = microSiemens per centimeter.

^b mg/L = milligrams per liter.

^c mV = millivolts.

^d NA = Not analyzed.

^e Duplicate sample of W22.

^f ND = Analyte not detected.

Note: TOC = total organic carbon.

geochemical evidence indicates that microbial consumption of the carbon is occurring within the contaminant plumes at LF-06.

4.4.1.2 Inorganic Chemistry

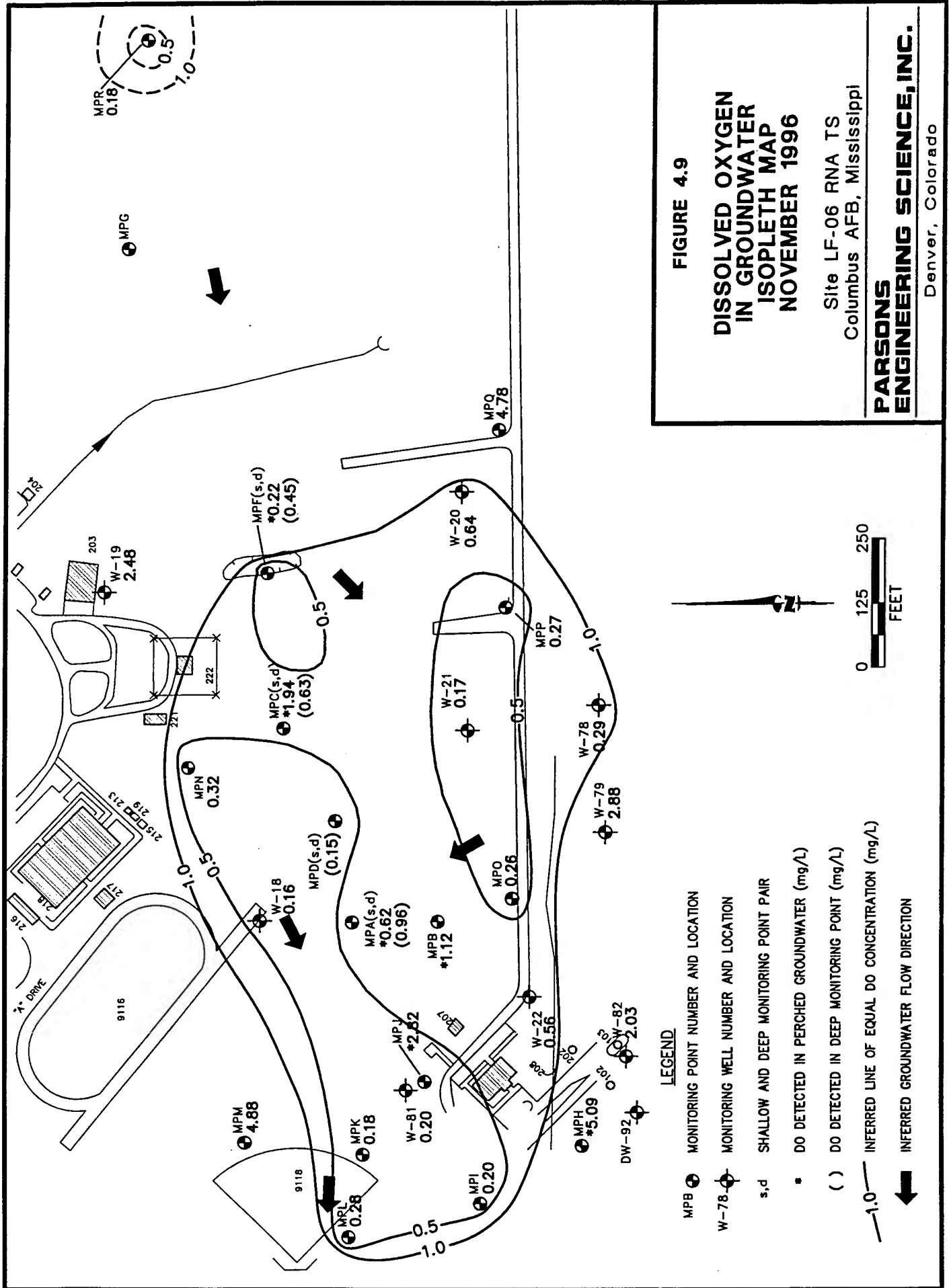
An interpretation of inorganic groundwater geochemistry, including isopleth maps for typical electron acceptors, can provide information regarding the relative importance of various biodegradation mechanisms and whether the conditions at the site are favorable for reductive dehalogenation of chlorinated compounds. Numerous geochemical parameters were evaluated in site groundwater samples. Analytical results for geochemical parameters measured in site samples are presented in Tables 4.4 and 4.5. The following paragraphs discuss those parameters that are most useful in the evaluation of site biodegradation processes.

4.4.1.2.1 Dissolved Oxygen

DO concentrations were measured at monitoring wells and points during the November 1996 sampling event. Concentrations ranged from 0.15 to 5.1 mg/L (Table 4.4), with the highest concentrations measured in wells/points outside of the area of the contaminant plumes. Within the plume area, concentrations were generally below 1.0 mg/L, except in some of the monitoring points screened in perched zones. Figure 4.9 illustrates DO concentrations at the site. The low concentrations of oxygen in the plume area relative to upgradient and crossgradient concentrations is a strong indication of biological activity in the plume area. Depletion of DO within the BTEX and chlorinated solvent plumes at LF-06 indicates that microbial activity stimulated by the presence of anthropogenic hydrocarbons (e.g., BTEX, chlorobenzenes, VC, DCA, DCE, or other components of landfill waste) is consuming DO and creating anaerobic conditions.

4.4.1.2.2 Nitrate/Nitrite

Concentrations of nitrate/nitrite [as nitrogen (N)] were measured in groundwater samples collected in November 1996. Table 4.4 summarizes measured nitrate/nitrite

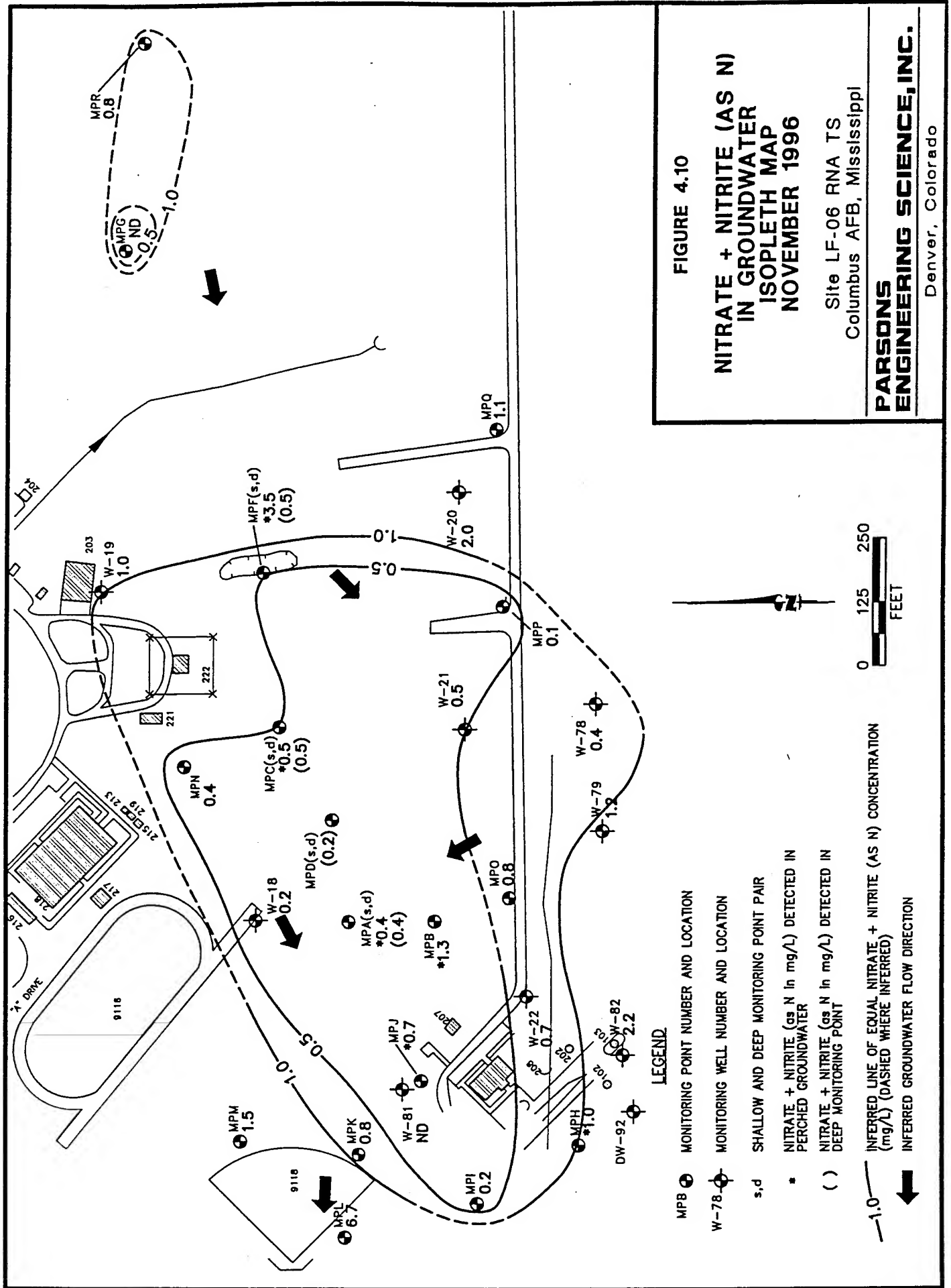


(as N) concentrations, and Figure 4.10 shows the distribution of nitrate/nitrite (as N) concentrations in site groundwater. Background concentrations range from about 1 mg/L to 6.7 mg/L, with most below 2.2 mg/L. Within the plume, nitrate concentrations are generally less than 0.5 mg/L, with some higher concentrations detected in perched groundwater or at the fringes. The area of reduced nitrate concentrations also coincides with the area of reduced DO concentrations, indicating that as DO is removed, microbes are utilizing nitrate as an electron acceptor for degradation of organic material (such as BTEX or native organic carbon).

4.4.1.2.3 Ferrous Iron

Ferrous iron [iron (II)] concentrations were measured in groundwater samples collected in November 1996. Table 4.4 summarizes ferrous iron concentrations. Measured ferrous iron concentrations range from 0.01 mg/L to 95.5 mg/L. Figure 4.11 shows the areal extent of ferrous iron in groundwater. Elevated ferrous iron concentrations coincide with the solvent and BTEX plumes. This suggests that ferric iron [iron (III)] hydroxide is being reduced to ferrous iron during biodegradation of native organic carbon, BTEX compounds, and possibly less-chlorinated solvents. Background levels of ferrous iron appear to range from below detection limits (0.05 mg/L) to about 3.0 mg/L, as measured at upgradient and crossgradient wells.

Recent evidence suggests that the reduction of ferric iron to ferrous iron cannot proceed at all without microbial mediation (Lovley and Phillips, 1988; Lovley *et al.*, 1991; Chapelle, 1993). None of the common organic compounds found in low-temperature (i.e., non-hydrothermal), neutral, reducing groundwater could reduce ferric oxyhydroxides to ferrous iron under sterile laboratory conditions (Lovley *et al.*, 1991). This means that the reduction of ferric iron requires microbial mediation by microorganisms with the appropriate enzymatic capabilities. Because the reduction of ferric iron cannot proceed without microbial intervention, the elevated concentrations of ferrous iron that were



measured in the contaminated groundwater at the site are very strong indicators of microbial activity.

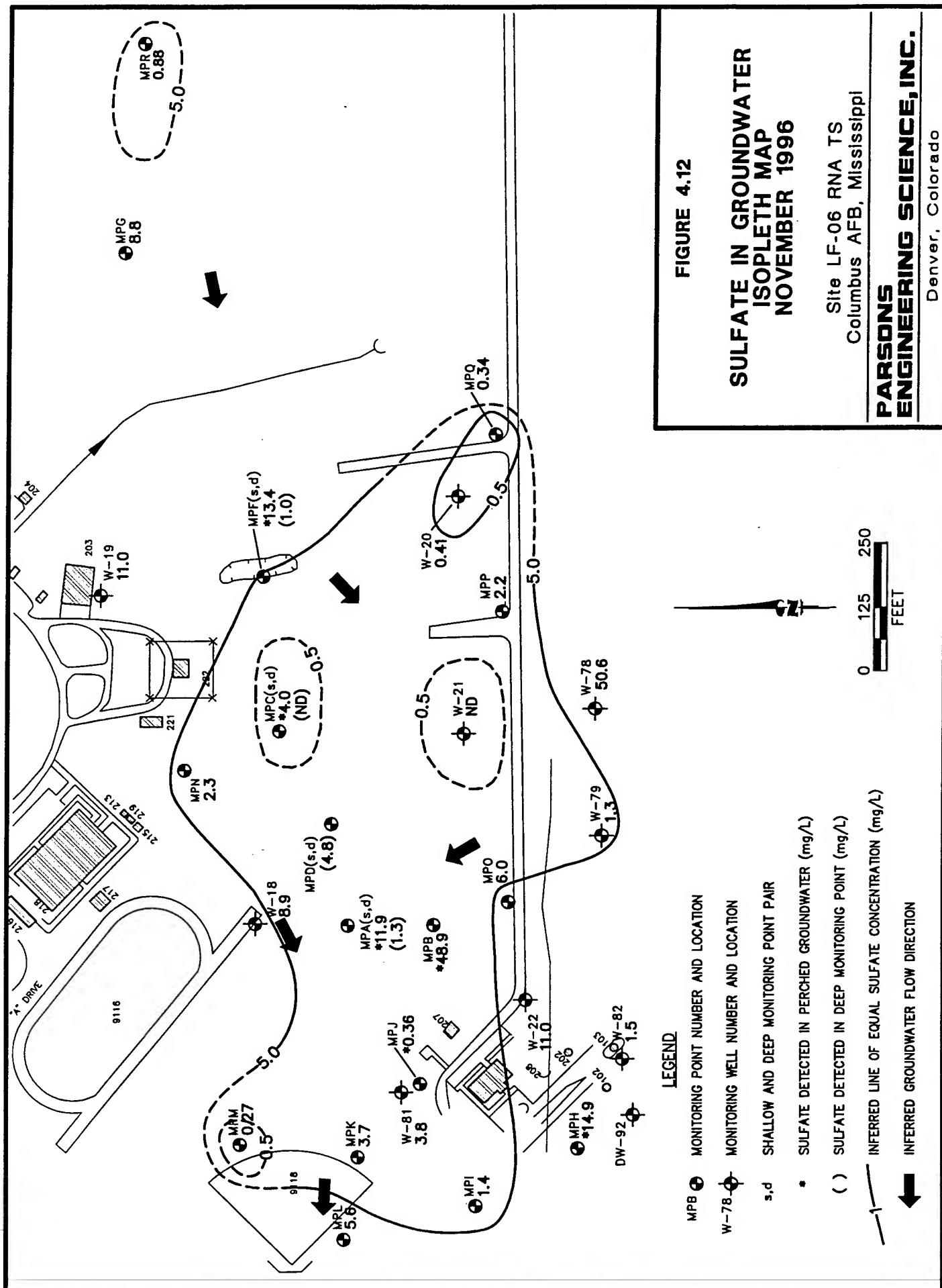
4.4.1.2.4 Sulfate

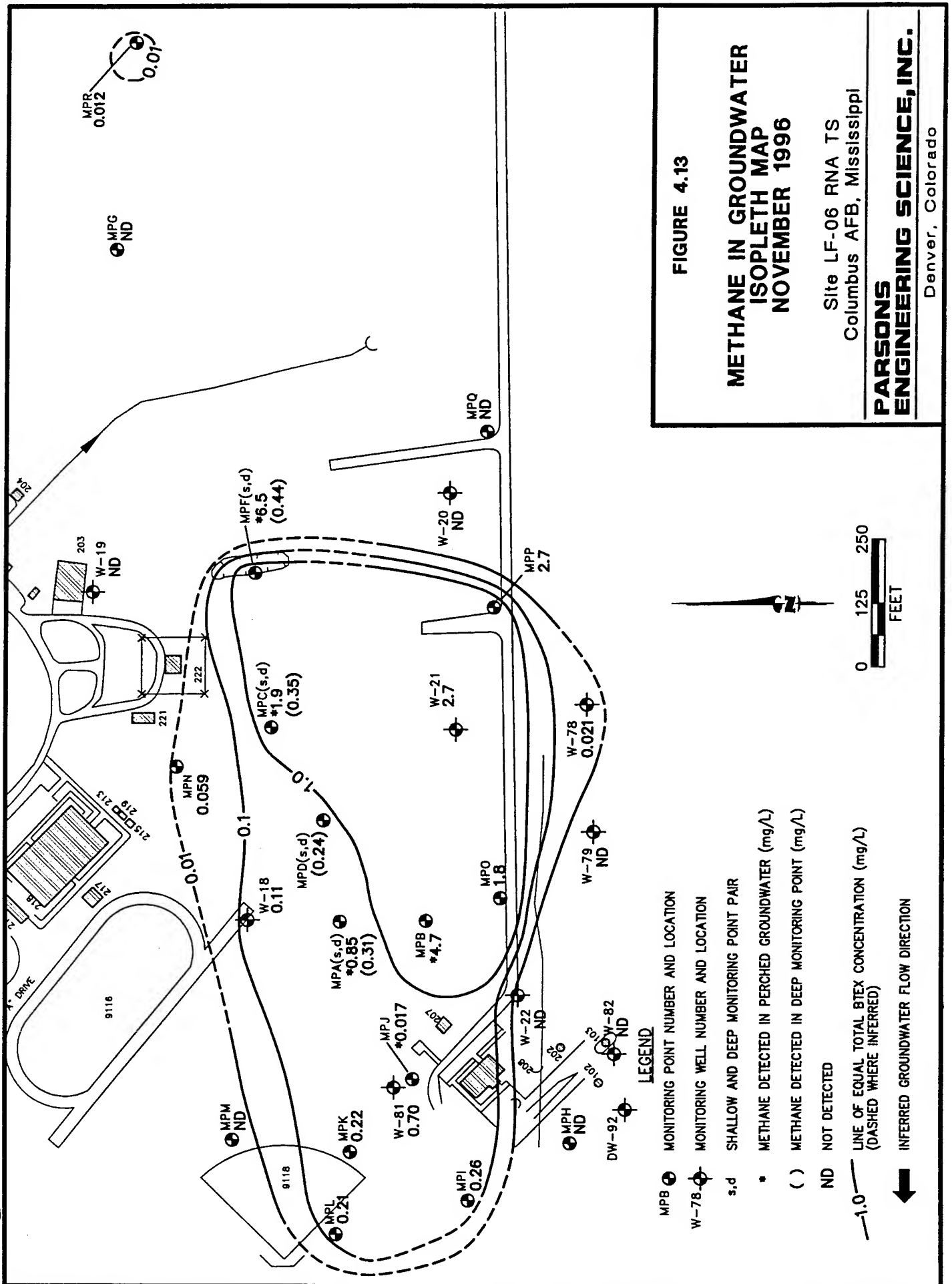
Sulfate concentrations were measured in groundwater samples collected in November 1996. Sulfate concentrations in shallow groundwater at the site ranged from 0.16 mg/L to 49 mg/L (Table 4.4). In general, the highest sulfate concentrations (ranging from about 15 mg/L to about 49 mg/L) were detected in wells outside of the area of the BTEX and chlorinated solvent plumes (Figure 4.12). Within the plume area, nearly all sulfate concentrations ranged from 0.16 mg/L to about 3 mg/L. Some sulfate concentrations within the plume area were as high as 26 mg/L, but these were typically for samples collected from perched wells/points.

The area of decreased sulfate concentrations correlates well with chlorinated solvent and BTEX concentrations. It is therefore likely that sulfate reduction is an ongoing anaerobic biodegradation process at LF-06. This is important because when a system is sufficiently reducing that sulfate reduction occurs, conditions become more favorable for reductive halogenation of solvents as BTEX or other electron donors are consumed.

4.4.1.2.5 Methane in Groundwater

Methane concentrations were measured in groundwater samples collected in November 1996. Table 4.4 lists methane concentrations, which ranged from less than 0.005 mg/L to 6.5 mg/L at the site. Figure 4.13 shows the distribution of methane in shallow site groundwater. The area of elevated methane concentrations correlates well with the chlorinated solvent and BTEX plumes. The presence of methane in the plume area indicates that conditions are sufficiently reducing that petroleum hydrocarbons and native organic matter are being used to support methanogenesis. Further, the fact that methanogenesis is ongoing indicates that conditions in the plume area are highly reducing and therefore favorable for reductive dehalogenation of chlorinated solvents.





As methanogenesis produces more carbon dioxide than it consumes, an unlimited supply of carbon dioxide is theoretically available once the process of methanogenesis has been initiated. Therefore, methanogenesis is limited by the rate of reaction rather than the source of electron acceptors.

4.4.2 Additional Geochemical Indicators

Other geochemical data collected for this evaluation can be used to further interpret and support the contaminant, electron donor, electron acceptor, and byproduct data previously discussed. These parameters provide additional qualitative indications of what processes may be operating at the site.

4.4.2.1 Oxidation/Reduction Potential

Redox potentials were measured at groundwater monitoring wells and points in November 1996. Redox potential is a measure of the relative tendency of a solution to accept or transfer electrons. The redox potential of a groundwater system depends on which electron acceptors are being reduced by microbes during oxidation of organic compounds. Redox potentials for shallow groundwater at the site range from 284 millivolts (mV) to -300 mV. Table 4.5 summarizes available redox potential data. In some locations, low redox potential coincide with areas of elevated BTEX and solvent concentrations, decreased DO, nitrate, and sulfate concentrations, and elevated ferrous iron and methane concentrations. However, this is not always the case and the correlation between redox potential and geochemical indicators is not strong.

Areas with low redox potentials tend to coincide with areas where there is evidence of ongoing reductive dehalogenation, except in the vicinity of W-21 and MPP. The redox potentials measured at those two locations were 216 mV and 67 mV, respectively. This apparent inconsistency may result from mismeasurement of redox potential due to sampling error or due to the fact that the instrument electrode has varying sensitivities to different redox couples, and thus does not always reflect the complete redox potential for a sample. This pattern may also indicate that concentrations of substrates have always been relatively

low and thus biodegradation reactions have not made significant and lasting changes in groundwater geochemistry in that area. In addition, it is also possible that the November 1996 data reflects that conditions that were formerly reducing changed to more oxidizing due to short-term or long-term changes in site conditions. Such a change may occur due to an influx of more oxidizing water (e.g., from a recharge event) or due to a long-term change in redox conditions due to decreasing substrate concentrations. Finally, the results may also be indicative of heterogeneity, such as a situation in which biodegradation is ongoing in one subunit of the shallow aquifer and the sampling of wells screened over multiple subunits results in mixing of waters from differing redox environments.

4.4.2.2 Alkalinity and Carbon Dioxide Evolution

Carbon dioxide is produced during the biodegradation of petroleum hydrocarbons and native organic carbon compounds. In aquifers that have carbonate minerals as part of the matrix, carbon dioxide forms carbonic acid, which dissolves these minerals, increasing the alkalinity of the groundwater. An increase in alkalinity (measured as CaCO_3) in an area with BTEX or chlorinated solvent (particularly less-chlorinated solvents) concentrations elevated above background conditions can be used to infer that petroleum hydrocarbons, less-chlorinated solvents, or native organic carbon has been destroyed through aerobic and anaerobic microbial respiration.

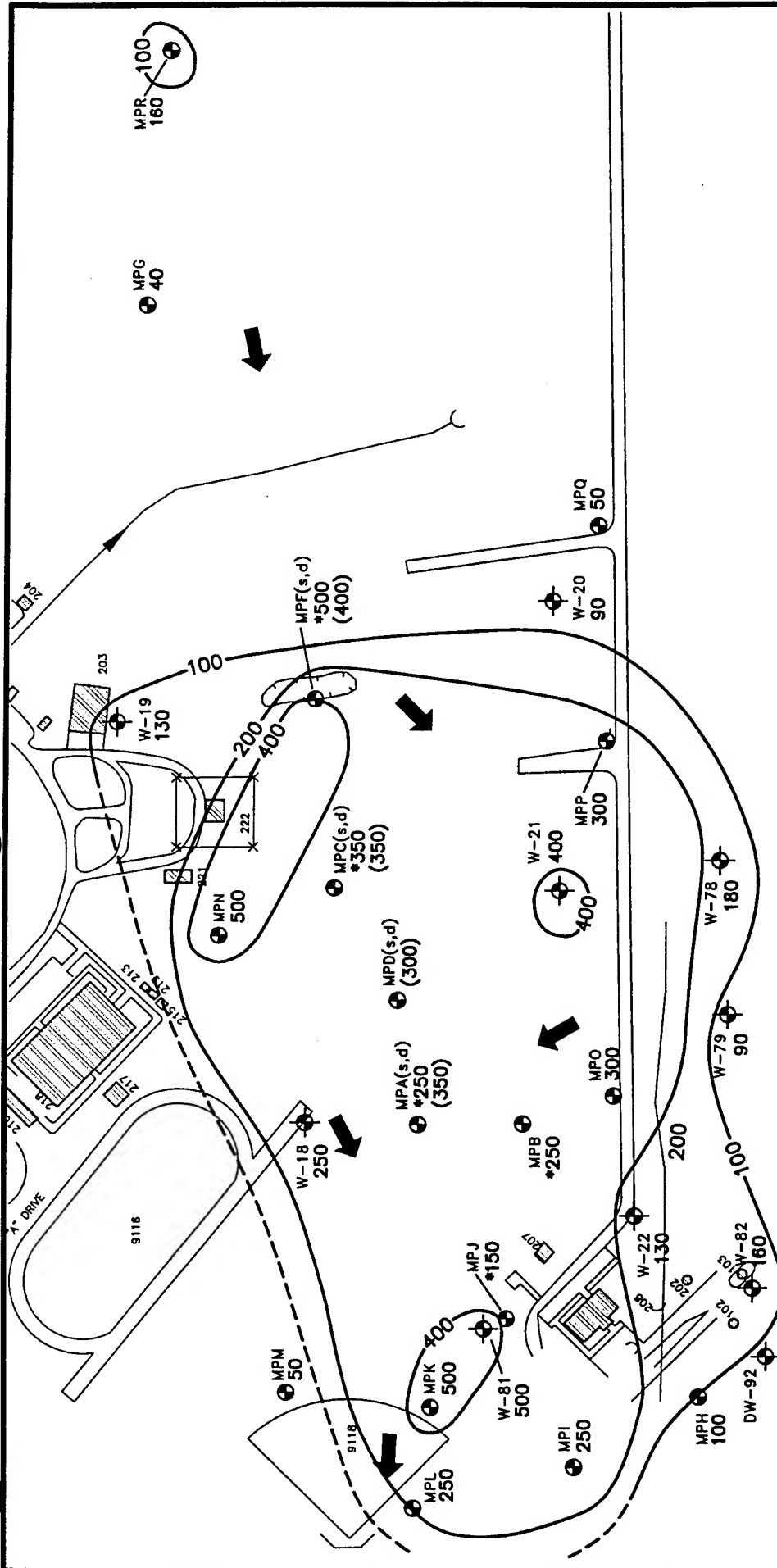
Total alkalinity (as CaCO_3) was measured in groundwater samples collected in November 1996. These measurements are summarized in Table 4.5. Alkalinity is a measure of the ability of groundwater to buffer changes in pH caused by the addition of biologically generated acids. Total alkalinity at the site varied from 0 mg/L to 425 mg/L, with the lowest concentrations generally measured in wells/points outside the contaminant plume. However, alkalinity within the plume area is variable, may not always be sufficient to buffer potential changes in pH caused by biologically mediated reactions. The pH data for site groundwater (Section 4.4.2.4) suggest that groundwater pH decreases slightly at some locations within the plume.

Free carbon dioxide concentrations also were measured in groundwater samples collected in November 1996 (Table 4.4). As shown on Figure 4.14, carbon dioxide concentrations within the full extent of the chlorinated solvent and BTEX plumes are elevated noticeably above background concentrations. Background concentrations are about 40 to 100 mg/L, while within the plume area, concentrations are in the range of 100 to 500 mg/L. Carbon dioxide concentrations above background result from both aerobic and anaerobic biodegradation processes as contaminants are ultimately converted to carbon dioxide and water.

4.4.2.3 Ammonia/Ammonium

The presence of ammonia/ammonium in groundwater can result from either nitrate reduction (facilitated by microbes) or fixing of atmospheric nitrogen (also a microbial process). Therefore, the presence of ammonia/ammonium in groundwater is a strong indication of microbial activity. Figure 4.15 shows the distribution of ammonia and ammonium (as N) concentrations measured in groundwater samples collected from LF-06. Ammonia/ammonium concentrations ranged from below detection limits to greater than 10 mg/L (Table 4.4), with the area of highest concentrations coinciding with the central portion of the contaminant plumes (i.e., centered along a line from MPF to MPA to W-81, and between W-18 and MPB).

Given that the highest nitrate concentration observed in site groundwater was 6.7 mg/L and that the highest ammonia/ammonium concentrations are greater than 10 mg/L, the nitrogen component of the ammonia process cannot entirely be derived from nitrate and may come from atmospheric nitrogen gas. This implies that groundwater conditions within the BTEX and solvent plumes are reducing enough to support nitrogen fixation. Stumm and Morgan (1981) note that nitrogen fixation will occur when conditions are at least



LEGEND

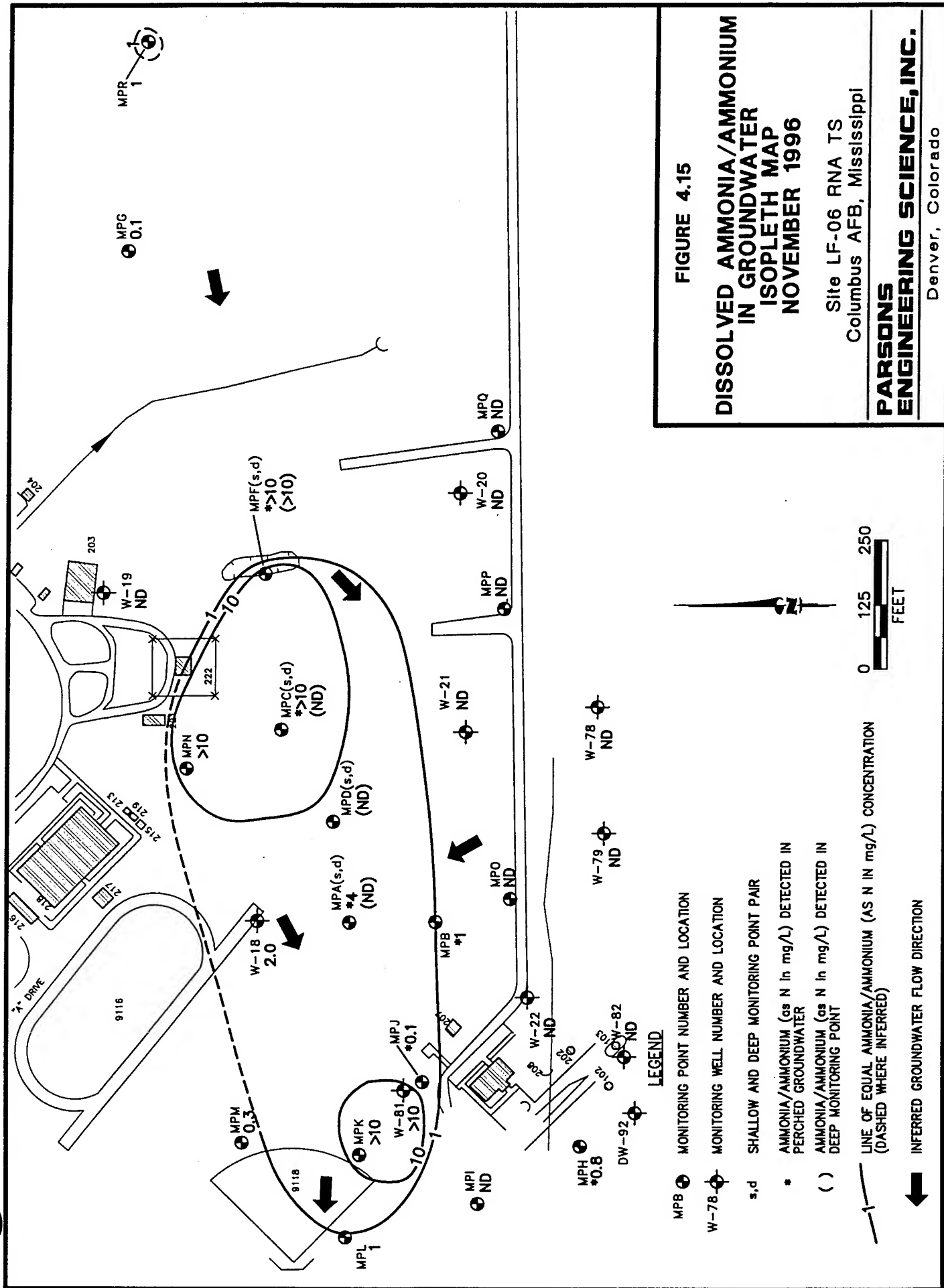
- MPB ● MONITORING POINT NUMBER AND LOCATION
- W-78 ● MONITORING WELL NUMBER AND LOCATION
- s,d SHALLOW AND DEEP MONITORING POINT PAIR
- * CARBON DIOXIDE DETECTED IN (mg/L)
- () CARBON DIOXIDE DETECTED IN (mg/L)
- LINE OF EQUAL CARBON DIOXIDE CONCENTRATION (mg/L)
(DASHED WHERE INFERRED)
- ➔ INFERRED GROUNDWATER FLOW DIRECTION

FIGURE 4.14

DISSOLVED CARBON DIOXIDE IN GROUNDWATER ISOPLETH MAP NOVEMBER 1996

Site LF-06 RNA TS
Columbus AFB, Mississippi

**PARSONS
ENGINEERING SCIENCE, INC.**
Denver, Colorado



reducing enough to support iron reduction. This process can also occur when sulfate reduction or methanogenesis is favored. Therefore, this evidence of nitrogen fixation further confirms that conditions within the solvent and BTEX plumes are sufficiently reducing to allow reductive dehalogenation to proceed. This also further confirms that organic matter (anthropogenic or natural) is being biodegraded in the plume area.

It is possible that some nitrate could enter groundwater from the landfill material; however, significant concentrations of nitrate in groundwater generally come from sources such as fertilizer, animal waste, sewage, and septic systems (Freeze and Cherry, 1979; Domenico and Schwartz, 1990). Thus, while it is possible that some nitrate may enter groundwater from material in the disposal trenches, it is more likely that nitrogen fixation is a more significant source of nitrogen for production of ammonia/ammonium.

4.4.2.4 pH

pH was measured for groundwater samples collected from groundwater monitoring points and monitoring wells in November 1996. These measurements are summarized in Table 4.5. The pH of a solution is the negative logarithm of the hydrogen ion concentration $[H^+]$. Groundwater pH measured at the site ranges from 4.3 to 6.8 standard units. This range of pH is slightly below the optimal range for BTEX-degrading microbes, although microbial activity can occur at a pH as low as 2 (Chapelle, 1993). The slightly acidic range of pHs also indicates that microbial reactions may have a noticeable effect on groundwater pH, likely due to the low background alkalinity of site groundwater (Section 4.4.2.2).

4.4.2.5 Temperature

Groundwater temperature was measured at groundwater monitoring points and monitoring wells in November 1996. Table 4.5 summarizes groundwater temperature readings. Temperature can affect the types and growth rates of bacteria that can be supported in the groundwater environment, with higher temperatures typically resulting in higher growth rates. Groundwater temperatures at LF-06 varied from 16.9°C to 20.8°C.

These are moderately warm temperatures for groundwater (but still within the optimal range), suggesting that bacterial growth rates should be high.

4.5 APPROXIMATION OF BIODEGRADATION RATES

Biodegradation rate constants are necessary to accurately simulate the fate and transport of contaminants dissolved in groundwater. In many cases, biodegradation of contaminants can be approximated using first-order kinetics. First-order biodegradation rate constants may be calculated on the basis of field-scale data, or by using a small sample of the aquifer material and groundwater for microcosm studies.

For reductive dehalogenation of chlorinated compounds, first-order rates are not necessarily an accurate representation because the degradation of CAHs depends on both the concentrations of electron donors (e.g., fuel hydrocarbons or native organic material) and the concentrations of electron acceptors (including inorganic acceptors and CAHs) (Moutoux *et al.*, 1996). Second-order rates would therefore allow more accurate modeling, but at this time there are no readily available groundwater contaminant transport models that can utilize such rates. Therefore, first-order rates must be estimated for such an application.

Microcosm studies are used to show that the microorganisms necessary for biodegradation are present and to help quantify rates of biodegradation. Because microcosm studies are time consuming and expensive, they should be undertaken only at sites where there is considerable skepticism concerning the biodegradation of contaminants. The results of a microcosm study are strongly influenced by the nature of the geological material submitted for study, the physical properties of the microcosm, the sampling strategy, and the duration of the study. Biodegradation rate constants determined by microcosm studies often are much higher than those observed in the field. Microcosms are most appropriate as indicators of the potential for natural bioremediation, and to prove that losses are biological, but it may be inappropriate to use them to generate rate constants.

The preferable method of contaminant biodegradation rate-constant determination is by use of field data.

In order to calculate first-order biodegradation rate constants on the field scale, the apparent degradation rate must be normalized for the effects of dilution, dispersion, and sorption. Two methods for determining first-order rate constants for BTEX compounds are described by Wiedemeier *et al.* (1996b). One method involves the use of a biologically recalcitrant compound found in the dissolved contaminant plume that can be used as a conservative tracer. The other method, proposed by Buscheck and Alcantar (1995), involves interpretation of a steady-state contaminant plume and is based on the one-dimensional, steady-state analytical solution to the advection-dispersion equation presented by Bear (1979). Both methods can be adapted to estimate rate constants for CAHs. Another method for estimating dehalogenation rates of CAHs is described by Moutoux *et al.* (1996). This method provides a total dechlorination rate for all dechlorination steps. All rates (including the rapid TCE to DCE rate and the slow VC to ethene) are averaged together using the Moutoux *et al.* (1996) method.

The method of Buscheck and Alcantar (1995) was used to estimate first-order biodegradation rate constants for BTEX and chlorinated solvents at LF-06. This method and the related calculations are summarized in Section 5.3. The other methods discussed above were not used because the low contaminant concentrations at LF-06 prevented proper analysis. Decay rates computed using data from LF-06 included a total BTEX biodegradation rate of 0.0053 day^{-1} , a chlorobenzene biodegradation rate of 0.010 day^{-1} , and a total chlorinated ethene dechlorination rate of 0.0035 day^{-1} . The equivalent half-lives are 0.35 years, 0.19 years, and 0.54 years, respectively.

4.6 DISCUSSION

Compounds detected in groundwater at LF-06 include BTEX, TCE, *cis*-1,2-DCE, 1,1-DCE, VC, 1,1,1-TCA, 1,1-DCA, CA, 1,3-DCB, 1,4-DCB, and CB. Of these compounds, only benzene, CB, TCE, and VC were detected at concentrations exceeding

MCLs. At only one location was a benzene concentration exceeding the MCL of 5 µg/L detected. At MPF(s), the benzene concentration was 12 µg/L. MPF(s) is screened in a perched zone, and the benzene concentration in the point below it [MPF(d), actually screened in the (continuous) shallow aquifer], the benzene concentration was only 2.1 µg/L.

CB was detected at a concentration of 200 µg/L in MPF(s), exceeding the MCL of 100 µg/L. In the sample from MPF(d), the CB concentration was only 6.1 µg/L. Also, no other CB concentration was greater than 23 µg/L (at MPN). TCE was detected in only 3 samples, and in only one (from W21) did the concentration (7.4 µg/L) exceed the MCL of 5 µg/L. VC was the most commonly detected compound exceeding standards, with concentrations exceeding the MCL of 2 µg/L detected in samples from 14 wells and monitoring points. However, none of these concentrations were greater than 10 µg/L.

Data have been collected from several wells at the site since 1988, and changes in concentrations of compounds present in concentrations exceeding MCLs over that time are shown in Table 4.6. Some concentrations have decreased slightly, but contaminant concentrations in single monitoring wells generally have fluctuated over time, with no clear overall trends of increasing or decreasing concentrations (i.e., some increase, some decrease, and some are relatively constant). This is likely a function of the low concentrations, mixing in wells during sampling, slight differences in sampling procedures, variations in plume concentrations due to water level/flow direction changes, and variable rates of desorption from aquifer solids.

TABLE 4.6
CONCENTRATION HISTORIES FOR COMPOUNDS DETECTED IN
GROUNDWATER IN CONCENTRATIONS EXCEEDING MCLs

SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Contaminant		Contaminant Concentration (µg/L)								
(MCL)	Well	Mar-88	Apr-88	Jul-88	Dec-88	May-89	Nov-91	Nov-94	Aug/Sep 95	Nov-96
TCE (5 µg/L)	W-21	NA ^{a/}	ND ^{b/}	ND	ND	ND	4J ^{c/}	26	26	7.4
	W-22	NA	ND	ND	ND	ND	14	ND	ND	ND
VC (2 µg/L)	W-18	NA	15	ND	NA	15	6J	8	ND	4.9
	W-20	NA	ND	ND	ND	9.8	NA	0.4J	ND	ND
	W-21	NA	26	ND	21	22	10	33	16	10
	W-81	NA	NA	NA	NA	NA	NA	6	ND	4.8
CB (100 µg/L)	W-18	NA	19	21	NA	21	ND	24	25	13
	W-20	NA	ND	ND	7	4.8	NA	ND	ND	ND
	W-21	NA	12	5	9	17	6	10	19	13
	W-81	NA	NA	NA	NA	NA	NA	12	13	6.5
	MPF(s) ^{d/}	NS ^{d/}	NS	NS	NS	NS	NS	NS	NS	200
Benzene (5 µg/L)	W-18	NA	ND	ND	NA	ND	2J	2	ND	1.3
	W-21	NA	ND	ND	ND	ND	2J	3	ND	3.6
	W-22	NA	ND	ND	ND	ND	20	ND	ND	ND
	W-81	NA	NA	NA	NA	NA	NA	2	ND	0.9
	MPF(s) ^{d/}	NS	NS	NS	NS	NS	NS	NS	NS	12
	W3 ^{d/}	NS	NS	NS	NS	NS	NS	NS	NS	15

^{a/} NA = not analyzed.

^{b/} ND = not detected.

^{c/} J = estimated concentration.

^{d/} Only location(s) where compound detected above MCL (in 1996).

^{e/} NS = not sampled.

In the case of CB, the one concentration exceeding the MCL was not detected until 1996, and then it was detected in MPF(s), which is screened in a perched zone. In the case of benzene, only one concentration exceeding the MCL was detected in new monitoring points [specifically, MPF(s)] in 1996. Previously, only one sample at another location (W-22 in November 1991) had contained benzene at a concentration exceeding the MCL. At that time, the benzene concentration was 20 µg/L, and was the only instance in which benzene was detected in that well. Of the other compounds detected in 1996 at concentrations that do not exceed standards (32 total detections), no single concentration exceeds 20 µg/L, and all but three of the 32 detected concentrations are under 10 µg/L.

The additional data collected for this effort also help to suggest three possible locations for sources of groundwater contamination in the LF-06 area. These locations include the apparent former trench in the vicinity of MPF, the area between MPP and W-21, and an area upgradient of MPN. The nature of these sources of fuel hydrocarbons and chlorinated solvents is not clear; however, the low dissolved concentrations do suggest that no mobile NAPL is present, and that the mass of each compound released to groundwater is not significant. The lack of information on the sources remains a problem because contaminant mass loading cannot be evaluated and the possibility of new releases cannot be discounted. However, the low concentrations of dissolved contaminants implies that existing sources are minor and that any future releases are likely to produce similar (low) concentrations.

Several lines of chemical and geochemical evidence indicate that the contaminants at LF-06 are being biodegraded, either as substrates or as electron acceptors. Geochemical data indicate that DO, nitrate, and sulfate are being consumed and iron (II) and methane are produced within that same area as the plume. This evidence suggests that microbial consumption of anthropogenic and natural organic matter (carbon compounds) is taking place at LF-06. Anthropogenic carbon compounds are present as petroleum hydrocarbons and less-chlorinated solvents (including, but not limited to, BTEX, chlorobenzene, VC,

DCE, and DCA) that are dissolved in groundwater, and probably as landfill leachate. Native carbon compounds include solid organic matter in the aquifer matrix and whatever portion of that matter that has dissolved into site groundwater. These compounds are electron donors in redox reactions that are also consuming electron acceptors (e.g., DO, ferric iron, carbon dioxide, and chlorinated hydrocarbons) and creating byproducts [e.g., methane, iron (II), and carbon dioxide]. Plots of contaminants, electron donors, electron acceptors, and byproducts of biodegradation reactions (Figures 4.3 through 4.15) provide strong qualitative evidence of these processes. Plots of additional indicators, such as carbon dioxide and ammonia concentrations, further indicate that biodegradation reactions are ongoing.

Microbial consumption of both native and anthropogenic organic carbon compounds destroys those compounds and creates conditions favorable for reductive dehalogenation. Site chemical data provide evidence of dehalogenation of TCE, DCE, TCA, and DCA. The presence of *cis*-1,2-DCE and VC in site groundwater coupled with evidence of sufficiently reducing conditions provides the primary line of chemical evidence for reductive dehalogenation of chlorinated ethenes. The presence of 1,1-DCA and CA also suggest that 1,1,1-TCA is being reductively dehalogenated in the central portion of the contaminant plume. The presence of dissolved methane further indicates that conditions are sufficiently reducing for the dehalogenation processes to proceed.

Elevated chloride concentrations within the solvent plumes also may indicate dehalogenation reactions, although chloride may also come from some of the wastes in the landfill and from oxidation of less-chlorinated compounds (i.e., utilization as a substrate). However, because of the other evidence of reductive dehalogenation, it is highly likely that some fraction of the excess chloride is a result of chlorinated solvent degradation. In addition, the fact that *cis*-1,2-DCE is detected instead of *trans*-1,2-DCE in wells/points where TCE or VC also are present is also indicative of biologically mediated reductive dehalogenation.

Evidence also suggests that 1,1,1-TCA is being abiotically dehydrohalogenated to 1,1-DCE at the margins of the contaminant plume. On the other hand, the absence of 1,1,1-TCA and the presence of 1,1-DCA and CA in wells that also contained BTEX and chlorinated ethenes suggests that reductive dechlorination of TCA is ongoing within the central area of the contaminant plume. It therefore appears that 1,1,1-TCA is reductively dehalogenated in the central plume area, while in the periphery wells (where conditions are less reducing), TCA is not reductively dechlorinated but instead reacts abiotically to form 1,1-DCE.

Given the available evidence, the dissolved CAH plume at LF-06 exhibits characteristics of both type 1 and type 3 behavior. Dissolved petroleum hydrocarbons and possibly some less-chlorinated solvents appear to act as carbon sources. It is likely that the introduction of petroleum hydrocarbons and solvents due to waste disposal activities stimulated additional microbial activity and made the groundwater system reducing enough to allow reductive dehalogenation of TCE, DCE, and TCA. VC has been created due to dehalogenation, but it is possible that it is being oxidized (as a substrate) once it enters aerobic groundwater. Likewise, it is possible that DCE and DCA are oxidized as well. However, conclusive evidence of these oxidation processes has not been gathered. It is possible that some microbial consumption of native organic matter is taking place outside the plume and within the plume, but the DO values measured outside of the contaminant plume suggest this process is minor. Type 2 behavior may therefore be limited in extent and is not discernible from consumption of contaminants.

As discussed in Section 4.5, rates of BTEX, chlorobenzene, and chlorinated ethene degradation estimated from data collected for this investigation were 0.010 day^{-1} , 0.018 day^{-1} , and 0.006 day^{-1} , respectively. As petroleum hydrocarbons and native organic matter continue to be consumed, reductive dehalogenation of the chlorinated ethenes will continue; however, once BTEX compounds are completely degraded, the rate at which dehalogenation proceeds may slow as the microbes utilize less easily degradable fuel

hydrocarbons or other organic matter. It also is conceivable that the plume may eventually come to display only type 3 behavior, but this will depend on the concentrations and degradability of the remaining (non-BTEX) fuel hydrocarbon compounds relative to the native organic matter.

As the type of organic matter used during biodegradation changes, the redox conditions also may change and alter which reactions are favored. This could also affect the rates at which CAHs are reductively dehalogenated, and could also cause dehalogenation of some compounds to cease. If and how this will happen is difficult to predict; the relative "degradability" of the native organic matter (or non-BTEX fuel hydrocarbons) and the effect of a changing electron donor source is not yet well-understood. It can be stated that if conditions become more oxidizing (but not aerobic), the dehalogenation of DCE may also cease or slow. However, aerobic and/or anaerobic mineralization of VC and DCE may become more important (i.e., type 3 conditions may dominate).

SECTION 5

GROUNDWATER MODELING

5.1 GENERAL OVERVIEW

To help estimate degradation rates for dissolved BTEX compounds and chlorinated solvents at LF-06 and to help predict the future migration of these compounds, Parsons ES modeled the fate and transport of the compounds that exceeded Mississippi Department of Environmental Quality (MDEQ) groundwater quality standards. The modeling effort has three primary objectives: (1) to predict the future extent and concentration of the dissolved contaminant plume by modeling the combined effects of advection, dispersion, sorption, and biodegradation; (2) to assess the potential for exposure of downgradient receptors to contaminant concentrations that exceed regulatory standards intended to be protective of human health and the environment; and (3) to provide technical support for the natural attenuation option at post-modeling regulatory negotiations, as appropriate. The model was developed using site-specific data and conservative assumptions about governing physical and chemical processes. Because of the conservative nature of model input, the reduction in contaminant mass caused by natural attenuation may exceed model predictions. This analysis is not intended to represent a baseline assessment of potential risks posed by site contamination.

Partial differential equations that describe groundwater flow and/or solute transport can be solved analytically or numerically. The type of model selected to simulate site conditions depends on the complexity of the problem, the amount of available data, the importance of the decisions that will be based upon the model, and project scope. Analytical methods (models) provide exact, closed-form solutions, and numerical methods

(models) provide approximate solutions. Analytical models are the simplest to set up and solve, allowing the user to evaluate many scenarios in a relatively short time. Numerical methods are more efficient for those systems that are too complex for analytical methods. Analytical models are restricted in the nature of the problems for which they can be used, and for some transport problems they may become so complex and unwieldy that the use of numerical methods may be more efficient. Theoretically, there are no limits on the characteristics of the hydrogeological system and the properties of the solute(s) that can be simulated using a numerical model code. There are, however, practical limits on the ways in which the system and any reactions within it can be represented. The basic parameters for both types of models typically include groundwater seepage velocity, hydraulic conductivity, saturated thickness of the aquifer, porosity, source area configuration, source area contaminant concentrations, leakage rates, dispersion coefficients, retardation values, and decay rates.

If limited data are available, or the hydrogeologic conditions are simple, an analytical model can be selected to simulate contaminant fate and transport. Analytical solutions provide exact, closed-form solutions to the governing advection-dispersion equation by making significant simplifying assumptions. Analytical solutions are most accurate where these assumptions closely approximate the actual system. Because of the nature of the simplifying assumptions, analytical models may overestimate or underestimate the spread of contamination. By making assumptions that will ensure the model will overpredict contaminant concentrations and travel distances (or at least not underpredict them), the model predictions will be conservative. The more conservative a model is, the more confidence there should be that potential receptors will not be impacted by site contamination. Analytical solutions are generally limited to steady, uniform flow or radial flow, and should not be used for groundwater flow or solute transport problems in strongly anisotropic or heterogeneous media.

Numerical solutions provide approximate solutions to the advection-dispersion equation. Numerical models are less burdened by simplifying assumptions and are capable of addressing more complicated problems. Unlike analytical models, numerical models allow subsurface heterogeneities and varying aquifer parameters to be simulated, as well as transient simulations (i.e., one or more properties or conditions change over time), if the requisite data are available. Many of the assumptions required for the analytical solutions are not necessary when numerical techniques are used to solve the governing solute transport equation. However, a greater amount of site-specific data is needed to implement a numerical model, and the solutions are inexact numerical approximations. The added complexity of performing a numerical model typically is not warranted unless the spatial distribution of input parameters is well documented.

Analytical models were selected to evaluate contaminant fate and transport at LF-06. Analytical models are appropriate at this site because the spatial variability regarding hydrogeologic conditions, geochemical measurements, and contaminant concentration information is limited. The models used with LF-06 data provided first-order solute decay solutions for a semi-infinite system with a constant point source (van Genuchten and Alves, 1982). The models assume a homogeneous, isotropic aquifer; a uniform, constant-velocity flow field in the x-direction only; a constant longitudinal hydrodynamic dispersion; a first-order rate of decay for biodegradation; and a linear sorption rate.

5.2 CONCEPTUAL MODEL DESIGN AND ASSUMPTIONS

Before developing a groundwater model, it is important to develop a reasonable interpretation of aquifer conditions. On the basis of the data presented in Section 3, the shallow saturated zone was conceptualized and modeled as a shallow unconfined aquifer composed of fine to medium sand with some gravel (Figure 3.3). Water level data suggest a relatively uniform local groundwater flow system without a significant vertical component.

Geochemical data presented in Section 4 suggest that biodegradation of site contaminants is occurring. In particular, BTEX and chlorinated solvent compounds are being degraded by aerobic respiration and the anaerobic processes of denitrification, ferric iron reduction, manganese reduction, sulfate reduction, nitrogen fixation, and methanogenesis. In addition, the processes of reductive dehalogenation and dehydrohalogenation are currently reducing the dissolved chlorinated solvent mass. Current analytical data on dissolved BTEX and chlorinated solvent concentrations were used for model calibration and to support solute reduction assumptions; historical information was limited to the landfill periphery, and therefore, was of limited use for hot spot identification, plume definition, and model calibration.

5.3 INITIAL MODEL SETUP

Where possible, the initial setup for the models was based on site data. Where site-specific data were not available (e.g., for effective porosity), reasonable assumptions were made on the basis of widely accepted literature values. The analytical model solution is based on calculations for retarded flow with biodegradation and a decaying source (van Genuchten and Alves, 1982). However, because of the lack of historical site data and information, it was assumed that the source(s) present at LF-06 would remain constant over time (i.e., no decay). The following sections describe the basic model setup. The analytical model parameters that were varied during model runs are discussed in Section 5.6.

5.3.1 Groundwater Gradient

The November 1996 water table elevation map presented on Figure 3.5 was used to determine the hydraulic gradient. Groundwater flow in the vicinity of the site is to the west with an average gradient of approximately 0.006 ft/ft. Due to the lack of consistent historical groundwater elevation data, it was assumed that the November 1996 water levels and gradient are representative of steady-state conditions.

5.3.2 Dissolved Contaminant Concentrations

Models were constructed for compounds with dissolved concentrations exceeding MDEQ regulatory limits, including benzene, CB, TCE, and VC. Tables 4.2 and 4.3 present November 1996 dissolved BTEX and chlorinated solvent concentration data. Figures 4.3 through 4.7 show the areal distribution of selected dissolved contaminants in November 1996. The shape and distribution of the contaminant plumes are the result of advective-dispersive transport and biodegradation of dissolved contamination originating from the source areas at LF-06. The highest dissolved concentrations from the November 1996 site investigation were used in the models to project future downgradient concentrations.

5.3.3 Degradation Rates

Available data strongly suggest that aerobic and anaerobic degradation processes are occurring at the site. As with a large number of biological processes, biodegradation can generally be described using a first-order rate constant and the equation:

$$\frac{C}{C_0} = e^{-kt}$$

where: C = Contaminant Concentration at Time t
C₀ = Initial Contaminant Concentration
k = Coefficient of Decay (decay rate constant)
t = time

Two methods of calculating rate constants are currently available to quantify rates of biodegradation at the field scale. The first method involves the use of a biologically recalcitrant compound as a conservative tracer. The second method, proposed by Buscheck and Alcantar (1995), involves interpretation of a steady-state contaminant plume configuration and is based on the one-dimensional steady-state analytical solution to the advection-dispersion equation presented by Bear (1979). An acceptable tracer could not be found for any of the individual chlorinated and nonchlorinated compounds in groundwater;

therefore, only the Buscheck and Alcantar method for estimating biodegradation rates was used to calculate site and chemical specific decay rates.

Buscheck and Alcantar (1995) derive a relationship that allows calculation of first-order decay rate constants for steady-state plumes. This method involves coupling the regression of contaminant concentration (plotted on a logarithmic scale) versus distance downgradient (plotted on a linear scale) to an analytical solution for one-dimensional, steady-state, contaminant transport that includes advection, dispersion, sorption, and biodegradation. For a steady-state plume, the first-order decay rate is given by (Buscheck and Alcantar, 1995):

$$\lambda = \frac{v_c}{4\alpha_x} \left(\left[1 + 2\alpha_x \left(\frac{k}{v_x} \right) \right]^2 - 1 \right)$$

where: λ = first-order decay rate
 v_c = retarded contaminant velocity in the x-direction
 α_x = dispersivity
 k/v_x = slope of line determined from a log-linear plot of contaminant concentration versus distance downgradient along flow path

The first-order decay rate includes biodegradation resulting from both aerobic and anaerobic processes; however, in the absence of oxygen, the first-order rate is equivalent to the anaerobic decay rate. Table 5.1 presents the data for a first-order rate constant calculation for BTEX using November 1996 data at LF-06 and the method proposed by Buscheck and Alcantar (1995). An exponential fit to the data estimates a log-linear slope of 0.0021. This value translates to a decay constant of 0.0053 day^{-1} which was used in the BTEX and benzene models. Calculated decay constants for chlorobenzene (Table 5.2) and chlorinated ethenes (Table 5.3) were 0.010 day^{-1} and 0.0035 day^{-1} , respectively. These rates were used in the analytical fate and transport models for chlorobenzene (0.010 day^{-1}) and TCE and VC (0.0035 day^{-1}).

A review of recent literature indicates that similar or higher rate constants generally have been observed in anaerobic plumes at other sites. For example, Chapelle (1994)

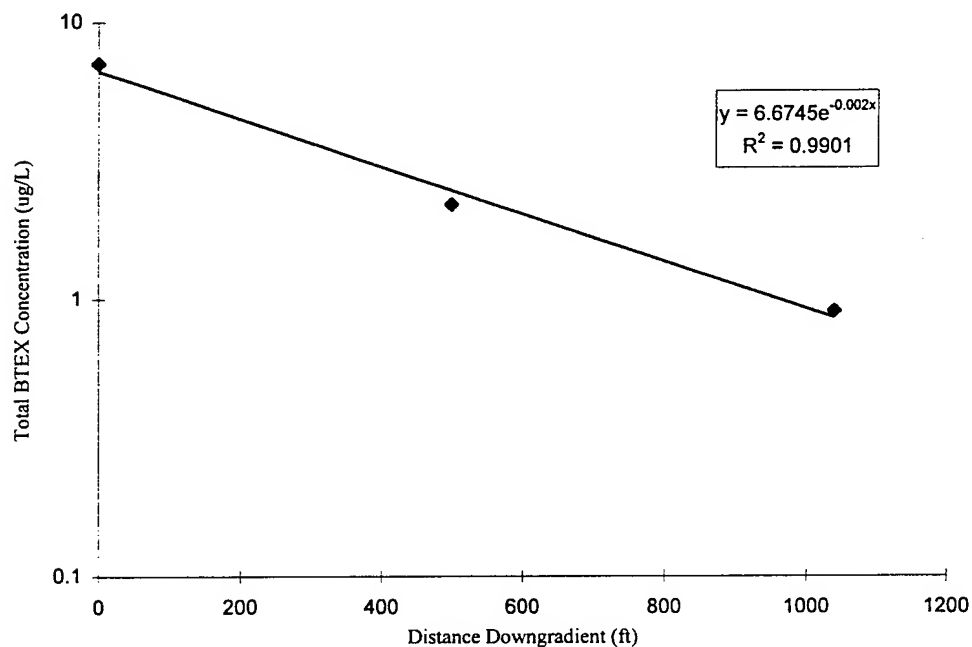
TABLE 5.1
FIRST-ORDER RATE CONSTANT CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)

LF-06

REMEDATION BY NATURAL ATTENUATION TS
COLUMBUS AFB, MISSISSIPPI

Point	Distance	Total BTEX (µg/L)
	Downgradient from Source (ft)	Oct-96
MPF	0	7.1
MPD	500	2.2
W-81	1040	0.9

PLOT OF TOTAL BTEX CONCENTRATION VERSUS DISTANCE



$$\lambda = v_e/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$$

where $v_e = 2.2000$ ft/day
 $\alpha_x = 100$ ft
 $k/v = 0.002$ ft-1
therefore $\lambda = 0.0053$ day-1

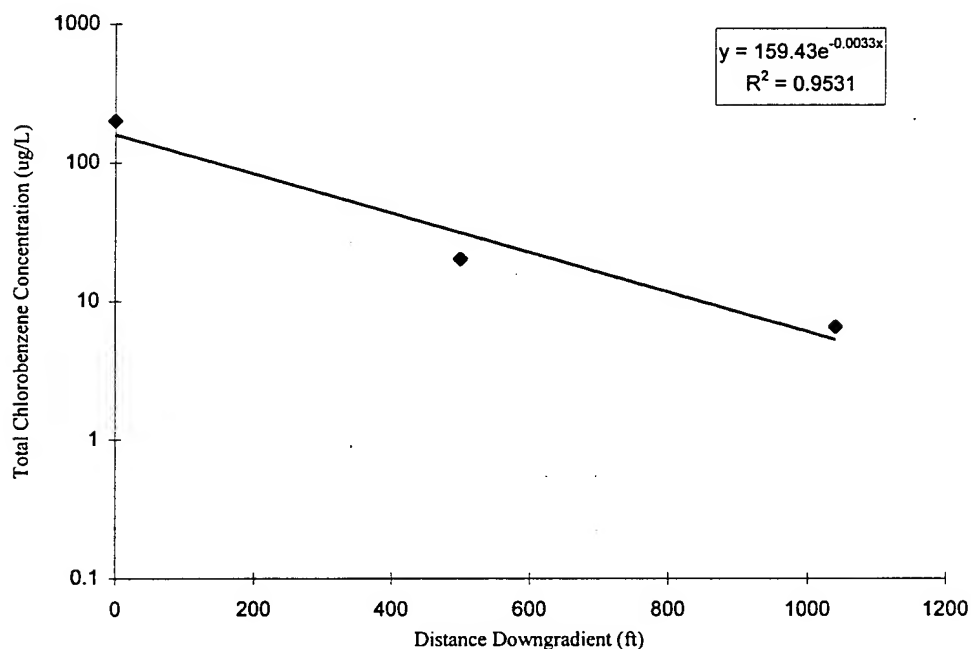
TABLE 5.2
FIRST-ORDER RATE CONSTANT CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)

LF-06

REMEDATION BY NATURAL ATTENUATION TS
COLUMBUS AFB, MISSISSIPPI

Point	Distance Downgradient from Source (ft)	Chlorobenzene (µg/L) Oct-96
MPF	0	200
MPA	500	20
W-81	1040	6.5

**PLOT OF TOTAL CHLOROBENZENE CONCENTRATION VERSUS
DISTANCE**



$$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$$

where $v_c = 2.2000$ ft/day
 $\alpha_x = 100$ ft
 $k/v = 0.0033$ ft-1
therefore $\lambda = 0.010$ day-1

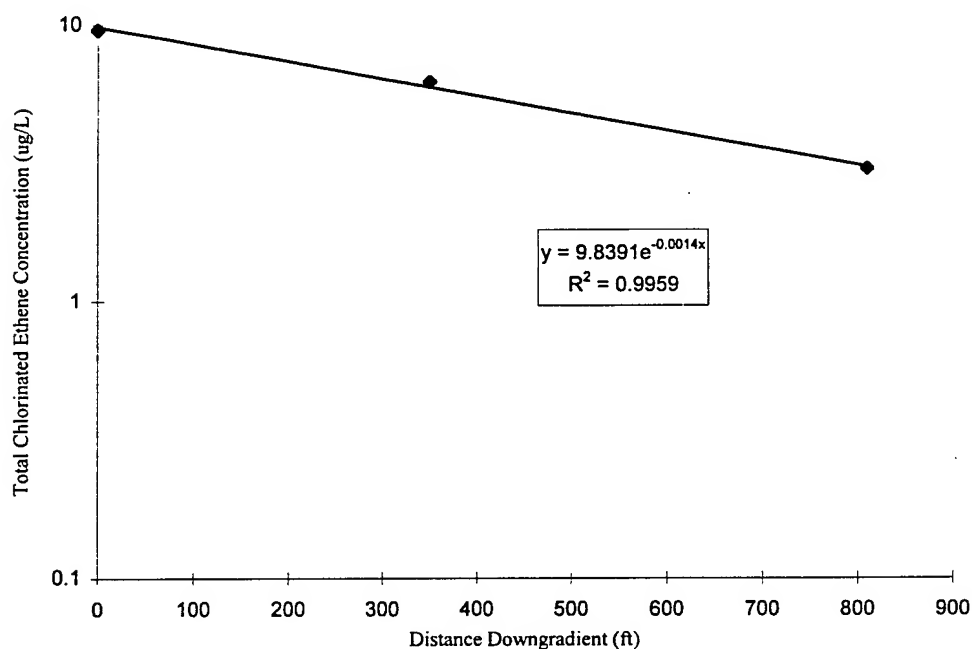
TABLE 5.3
FIRST-ORDER RATE CONSTANT CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)

LF-06

REMEDATION BY NATURAL ATTENUATION TS
COLUMBUS AFB, MISSISSIPPI

Point	Distance Downgradient from Source (ft)	Total Chlorinated Ethenes (µg/L) Oct-96
MPN	0	9.6
W-18	350	6.2
MPK	810	3

**PLOT OF TOTAL CHLORINATED ETHENE
CONCENTRATION VERSUS DISTANCE**



$$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$$

where $v_c = 2.2000$ ft/day
 $\alpha_x = 100$ ft
 $k/v = 0.0014$ ft-l
therefore $\lambda = 0.0035$ day⁻¹

reported that at two different sites with anaerobic groundwater conditions the rate constants were both approximately 0.01 day^{-1} . Wilson *et al.* (1994) report first-order anaerobic biodegradation rates of 0.05 to 1.3 week^{-1} (0.007 to 0.185 day^{-1}); Buscheck *et al.* (1993) report first-order attenuation rates in a range of 0.001 to 0.01 day^{-1} ; and Stauffer *et al.* (1994) report rate constants of 0.01 and 0.017 day^{-1} for benzene and *p*-xylene, respectively.

5.4 MODEL CALIBRATION

True model calibration was not performed due to the lack of source area and site information. However, using known site specific hydrogeological information, a site specific biodegradation rate for BTEX compounds, and a source concentration equal to the highest observed concentration, it was shown (Model-BTEX) that the current extent of the dissolved BTEX plume was accurately simulated at steady-state conditions. Furthermore, Model-BTEX predicted that the dissolved BTEX plume would reach steady state in just over 1 year with constant input terms. Knowing that Model-BTEX accurately predicted the extent of dissolved BTEX contamination, the remaining predictive models were also run using the same hydrogeologic parameters: a hydraulic gradient of 0.0055 ft/ft , hydraulic conductivity of 99 ft/day , effective porosity of 0.25 , and TOC of 0.06 percent .

To model contaminant distribution for the contaminants of concern (benzene, CB, TCE, VC), it was also assumed that no annual source decay occurred. Assuming no annual source decay may not be an accurate representation of site conditions because it does not account for natural degradation of the source as well as dissolution of the source into groundwater; however, the assumption makes predictive models potentially conservative. The compound specific solute decay rates also were used in predictive models (Section 5.3.3). The highest observed concentrations of the compounds of concern were used as the source input terms for each respective model.

5.5 MODEL RESULTS

Four models were run to predict how far downgradient dissolved concentrations of contaminant of concern (benzene, TCE, CB, VC) exceeded state groundwater criteria (Section 6). Because source decay was not incorporated into the predictive models, time to remediation is not evaluated in this TS. However, assuming that contaminant concentrations exceeding state groundwater standards would persist throughout time (lack of historical site information makes this assumption valid), estimates of contaminant plume length were predicted. Model input and output are presented in Appendix C.

Model-BZ presents the predicted lateral extent of dissolved benzene concentrations at steady state conditions (approximately mid 1998). Using the November 1996 highest observed benzene concentration of 15 $\mu\text{g/L}$ (monitoring point MPF), Model-BZ predicted that dissolved benzene concentrations would exceed the 5 $\mu\text{g/L}$ state groundwater standard for approximately 360 feet west of (downgradient from) monitoring point MPF. At point MPC, the closest downgradient from MPF, the observed benzene concentration was less than 2 $\mu\text{g/L}$. The fact that this point is approximately 300 feet downgradient suggests that the model is conservative.

Model-CB presents the predicted lateral extent of dissolved chlorobenzene concentrations at steady state conditions. Assuming a source area concentration of dissolved chlorobenzene of 200 $\mu\text{g/L}$ (observed at monitoring point MPF in November 1996), Model-CB predicts that CB concentrations will exceed the state groundwater standard of 100 $\mu\text{g/L}$ for approximately 100 feet downgradient from the point source MPF. This model slightly underpredicts observed downgradient concentrations; however, a concentration of CB in a perched groundwater zone at MPC suggests that observed concentrations may have been boosted by a minor secondary source.

Model-TCE presents the predicted lateral extent of dissolved TCE concentrations at steady state conditions. Assuming a source area concentration of dissolved TCE of 7.5 $\mu\text{g/L}$ (observed at W21 in November 1996), Model-TCE predicts that TCE concentrations

will exceed the state groundwater standard of 5 $\mu\text{g/L}$ for approximately 165 feet downgradient from the point source W21. This rate of decrease is slightly conservative.

Model-VC presents the predicted lateral extent of dissolved VC concentrations at steady state conditions. Assuming a source area concentration for dissolved VC of 10 $\mu\text{g/L}$ (observed at W21 in November 1996), Model-VC predicts that VC concentrations will exceed the state groundwater standard of 2 $\mu\text{g/L}$ for approximately 1,000 feet downgradient from the point source W21. The observed VC plume actually migrates approximately 500 feet downgradient from W21. The plume that originates at MPF stretches for approximately 1,500 feet; however, several minor sources may be contributing to the plume extent. Furthermore, this VC plume extends only about 500 feet downgradient from the edge of the landfill.

5.6 SENSITIVITY ANALYSIS

The purpose of the sensitivity analysis is to determine the effect of varying model input parameters on model output. The sensitivity analysis for model input parameters was conducted on Model-BTEX by varying hydraulic conductivity (± 2 times), the organic carbon content (± 2 times), effective porosity ($\pm 25\%$), dispersivity (± 2 times), and the solute decay rate (± 2 times). To perform the sensitivity analyses, the model was run with the same input as the original predictive model excepting the tested parameter. The models were run for a 2-year period so the effects could be compared to steady state conditions simulated by the predictive models, also using a 2-year period. Model output data from the sensitivity analysis are presented in Appendix C.

The results of the sensitivity analysis suggest that the models are most sensitive to hydraulic conductivity, total organic carbon, and solute decay, and less sensitive to effective porosity and dispersivity. Increasing hydraulic conductivity significantly increased the distance of plume migration and the downgradient concentrations of dissolved contaminants, because advective-dispersion mechanisms are more significant with the higher groundwater velocity that results from a higher hydraulic conductivity. Conversely,

decreasing the hydraulic conductivity to half the observed value decreases the distance of plume migration to less than the distance observed in November 1996. Increasing the total organic carbon content decreases the distance of plume migration to less than the distance observed in November 1996. A decrease in the organic carbon content had the opposite effects on the modeled BTEX plume. Changes to the modeled dissolved BTEX plume arising from varying the effective porosity are similar to the changes observed with varying TOC; however, over the evaluated ranges, effective porosity had a smaller effect on the predicted plume than TOC. Changes in the dispersivity value had a similar, but less pronounced, effect on the predicted contaminant plume as did changes to the hydraulic conductivity. Increasing the solute decay rate by two caused the model to produce a contaminant plume of lesser extent than observed in November 1996. Decreasing the solute decay rate made the predicted 1996 plume more than two times as large as the plume observed in November 1996.

The results of the sensitivity analysis indicate that the calibrated model is generally reasonable. Varying the model parameters within the prescribed ranges generally caused the extent and magnitude of the dissolved BTEX plume to differ noticeably from measured conditions.

SECTION 6

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the development and comparative analysis of groundwater remedial alternatives for contaminated groundwater at Site LF-06. The intent of this evaluation is to determine if RNA of groundwater is an appropriate and cost-effective remedial approach to consider when developing final remedial strategies for the study area, especially when combined with other remedial technologies.

Section 6.1 presents the criteria used to evaluate groundwater remedial alternatives. Section 6.2 discusses the development of remedial alternatives considered as part of this demonstration project. Section 6.3 provides a brief description of each of these remedial alternatives. Section 6.4 provides a more detailed analysis of the remedial alternatives using the defined remedial alternative evaluation criteria. The results of this evaluation process are summarized in Section 6.5.

6.1 REMEDIAL ALTERNATIVE EVALUATION CRITERIA

The evaluation criteria used to identify appropriate remedial alternatives for shallow groundwater contamination at the site were evaluated on the basis of (1) long-term effectiveness and permanence, (2) technical and administrative implementability, and (3) relative cost. The following sections briefly describe the scope and purpose of each evaluation criterion. This report focuses on the potential use of RNA to reduce dissolved BTEX and chlorinated solvent concentrations in the shallow groundwater below MCLs. Source reduction is not considered because the sources at LF-06 have not been identified and are likely scattered throughout the burial area.

6.1.1 Long-Term Effectiveness and Permanence

Each remedial alternative (which can be a combination of remedial approaches such as RNA and institutional controls) was analyzed to determine how effectively it will minimize groundwater plume expansion so that groundwater and surface water quality standards can be achieved at a downgradient sentry well. The expected technical effectiveness based on case histories from other sites with similar conditions also is evaluated. The ability to minimize potential impacts on surrounding facilities and operations is considered. Also, the ability of each remedial alternative to protect both current and potential future receptors from potential risks associated with potentially completed exposure pathways is qualitatively assessed. This evaluation criterion also included permanence and the ability to reduce contaminant mass, toxicity, and volume. Time to implementation and time until protection is achieved are described. Long-term reliability for providing continued protection, including an assessment of potential for failure of the technology and the potential threats resulting from such a failure, also is evaluated.

6.1.2 Implementability

The technical implementability of each remedial technology or remedial alternative was evaluated in terms of technical feasibility and availability. Potential shortcomings and difficulties in construction, operations, and monitoring are presented and weighed against perceived benefits. Requirements for any post-implementation site controls such as LTM and land use restrictions are described. Details on administrative feasibility in terms of the likelihood of public acceptance and the ability to obtain necessary approvals are discussed.

6.1.3 Cost

The total cost (adjusted to present worth) of each remedial alternative was estimated for relative comparison. An estimate of capital costs, and operating and post-implementation costs for site monitoring and controls is included. An annual adjustment (discount) factor of 7 percent was assumed in present worth calculations. The annual adjustment factor is the difference between the rate of inflation and the cost of money (USEPA, 1993).

6.2 FACTORS INFLUENCING ALTERNATIVES DEVELOPMENT

Several factors were considered during the identification and screening of remedial technologies for addressing shallow groundwater contamination at the site. Factors considered included the objectives of the AFCEE natural attenuation demonstration program; contaminant, groundwater, and soil properties; current and future land uses; and potential receptors and exposure pathways. The following section briefly describes each of these factors and how they were used to narrow the list of potentially applicable remedial technologies to the final remedial alternatives considered for the study area.

6.2.1 Program Objectives

The intent of the RNA demonstration program sponsored by AFCEE is to develop a systematic process for scientifically investigating and documenting natural subsurface attenuation processes that can be factored into overall site remediation plans. The objective of this program and the specific demonstration at Columbus AFB is to provide solid evidence of RNA of dissolved fuel hydrocarbons and chlorinated solvents so that this information can be used to develop an effective groundwater remediation strategy. A secondary goal of this multi-site initiative is to provide a series of regional case studies that demonstrate that natural processes of contaminant degradation can often reduce contaminant concentrations in groundwater to below acceptable cleanup standards before completion of potential receptor exposure pathways.

Because the objective of this program is to study natural processes in the saturated zone rather than all contaminated media (e.g., soil, soil gas, etc.), technologies have been evaluated based primarily on their potential impact on shallow groundwater and phreatic soils. Technologies that can reduce vadose zone contamination and partitioning of contaminants into groundwater also have been evaluated. Many of the source removal technologies evaluated in this section also will reduce soil and soil gas contamination, but it is important to emphasize that the remedial alternatives developed in this document are not intended to remediate all contaminated media. Additional program objectives set forth by

AFCEE include cost effectiveness and minimization of waste. Technologies that may best meet these AFCEE criteria include institutional controls, soil vapor extraction (SVE), bioventing, bioslurping, passive drain collection, biosparging, and RNA. Under this program, slurry walls, sheet piling, carbon adsorption, and groundwater extraction with *ex situ* biological or chemical treatment of groundwater are not considered attractive technologies.

6.2.2 Contaminant Properties

The site-related contaminants considered as part of this demonstration in the study area are the BTEX compounds, TCE, DCE, VC, 1,1,1-TCA, 1,1-DCA, CB, and 1,2-DCB. Of these compounds, only benzene, TCE, VC, and CB are present in concentrations exceeding MCLs. The primary sources of contamination at LF-06 are likely containers of waste scattered throughout the burial trenches; however, the exact location and nature of these sources is unknown.

The physiochemical characteristics of the individual compounds will greatly influence the effectiveness and selection of a remedial technology. Important characteristics for each of the compounds noted above are presented in the following paragraphs. These characteristics are listed for the purpose of a general comparison and a preliminary selection of remedial alternatives.

The BTEX compounds are generally volatile, highly soluble in water, and adsorb less strongly to soil than other hydrocarbons in a petroleum mixture. These characteristics allow the BTEX compounds to leach more rapidly from contaminated soil into groundwater, and to migrate as dissolved contamination (Lyman *et al.*, 1992). All of the BTEX compounds are highly susceptible to *in situ* degradation by both biotic and abiotic mechanisms.

Benzene is very volatile, with a vapor pressure of 76 millimeters of mercury (mm Hg) at 20°C and a Henry's Law Constant of approximately 0.0054 atmosphere-cubic meters per

mole ($\text{atm}\cdot\text{m}^3/\text{mol}$) at 25°C (Hine and Mookerjee, 1975; Jury *et al.*, 1984). The solubility of pure benzene in water at 20°C has been reported to be 1,780 mg/L (Verschuieren, 1983). Benzene is normally biodegraded to carbon dioxide, with catechol as a short-lived intermediate (Hopper, 1978; Ribbons and Eaton, 1992).

Toluene is also volatile, with a vapor pressure of 22 mm Hg at 20°C and a Henry's Law Constant of about $0.0067 \text{ atm}\cdot\text{m}^3/\text{mol}$ at 25°C (Pankow and Rosen, 1988; Hine and Mookerjee, 1975). Toluene sorbs more readily to soil media relative to benzene, but still is very mobile. The solubility of pure toluene in water at 20°C is approximately 515 mg/L at 20°C (Verschuieren, 1983). Toluene has been shown to degrade to pyruvate, caetaldehyde, and completely to carbon dioxide via the intermediate catechol (Hopper, 1978; Wilson *et al.*, 1986; Ribbons and Eaton, 1992).

Ethylbenzene has a vapor pressure of 7 mm Hg at 20°C and a Henry's Law Constant of $0.0066 \text{ atm}\cdot\text{m}^3/\text{mol}$ (Pankow and Rosen, 1988; Valsaraj, 1988). Ethylbenzene sorbs more strongly to soils than benzene and toluene (Kenaga and Goring, 1980; Means *et al.*, 1980; Hassett *et al.*, 1983; Fetter, 1993). Pure ethylbenzene is also less soluble than benzene and toluene in water at 152 mg/L at 20°C (Verschuieren, 1983; Miller *et al.*, 1985). Ethylbenzene ultimately degrades to carbon dioxide via its intermediate 3-ethylcatechol (Hopper, 1978; Ribbons and Eaton, 1992).

The three isomers of xylene have vapor pressures ranging from 7 to 9 mm Hg at 20°C and Henry's Law Constants of between 0.005 and $0.007 \text{ atm}\cdot\text{m}^3/\text{mol}$ at 25°C (Mackay and Wolkoff, 1973; Hine and Mookerjee, 1975; Pankow and Rosen, 1988). A compilation of literature values for sorption coefficients suggests that xylenes sorb to soil with approximately the same strength as ethylbenzene (Wiedemeier *et al.*, 1995). Pure xylenes have water solubilities of 152 to 160 mg/L at 20°C (Bohon and Claussen, 1951; Mackay and Shiu, 1981; Isnard and Lambert, 1988). Xylenes can degrade to carbon dioxide via pyruvate carbonyl intermediates (Hopper, 1978; Ribbons and Eaton, 1992).

The CAH compounds (e.g., TCE, DCE, VC, TCA, and DCA) are generally volatile, relatively soluble in water, and do not adsorb strongly to soil particles. These characteristics allow the CAHs to leach readily from NAPL and contaminated soil into groundwater, and to migrate as dissolved contamination (Lyman *et al.*, 1992). Many CAHs are amenable to *in situ* degradation by both biotic and abiotic mechanisms under certain geochemical conditions.

TCE is moderately volatile, with a vapor pressure ranging from 69 mm Hg to 74 mm Hg at 25°C (Mackay and Shiu, 1981; Klopffer *et al.*, 1988; Howard, 1990). Henry's Law Constants reported for TCE range from 0.0086 to 0.0102 atm-m³/mol at 25°C (Ashworth *et al.*, 1988; Dewulf *et al.*, 1995). The solubility of pure TCE in water at 20°C has been reported to be 1,100 mg/L (Pearson and McConnell, 1975). TCE biodegradation products vary according to the prevailing groundwater geochemistry, and are described in Section 4.2.

cis-1,2-DCE is very volatile, with a vapor pressure of 200 mm Hg at 25°C and a Henry's Law Constant of about 0.0037 atm-m³/mol. (reported in Wiedemeier *et al.*, 1996a). 1,1-DCE is also very volatile, with a vapor pressure of 591 mm of Hg at 25°C (Verschueren, 1983) and a Henry's Law Constant of 0.021 atm-m³/mol (Schwille, 1988). DCE tends to be slightly more mobile than TCE, with less of a tendency to adsorb to the aquifer matrix material. The solubility of *cis*-1,2-DCE in water at 25°C is approximately 3,500 mg/L (Howard, 1990). The solubility of 1,1-DCE is about 2,500 mg/L (Howard, 1989). The degradation of DCE is discussed in Section 4.2.

Vinyl chloride is extremely volatile, with a vapor pressure of 2,580 mm of Hg at 20°C (Lyman *et al.*, 1982) and a Henry's Law Constant of 0.056 atm-m³/mol at 25°C (Hine and Mookerjee, 1975). Vinyl chloride does not adsorb as well as either TCE or DCE (Karickhoff *et al.*, 1979). It is more mobile than TCE, DCE, and benzene in groundwater. The solubility of VC is about 1,100 mg/L at 25°C (Verschueren, 1983).

1,1,1-TCA is about as volatile as benzene, with a vapor pressure of 124 mm of Hg at 25°C and a Henry's Law Constant of about 0.008 atm-m³/mol. (reported in Wiedemeier *et al.*, 1996a). 1,1,1-TCA is slightly more prone to adsorption than TCE (Howard, 1990). The solubility of 1,1,1-TCA in water at 25°C is about 1,495 mg/L (Howard, 1990).

Similar to DCE, 1,1-DCA is very volatile, with a vapor pressure of 227 mm of Hg at 25°C and a Henry's Law Constant of about 0.006 atm-m³/mol (reported in Wiedemeier *et al.*, 1996a). 1,1-DCA is more mobile than TCA and DCE, but not as mobile as VC. The solubility of 1,1-DCA in water at 25°C is about 5,000 mg/L (Howard, 1989).

CB and DCB are less volatile and less soluble than CAHs, and are generally more likely to adsorb to soils. Their properties are generally similar to BTEX compounds. Under aerobic conditions, CB and DCB biodegrade in the same manner as benzene. Biodegradation of these compounds as substrates under anaerobic conditions has not been studied enough to have been documented in the scientific literature. However, the more chlorinated benzene compounds have been shown to undergo reductive dehalogenation.

CB is moderately volatile, with a vapor pressure of about 1.5 mm of Hg at 25°C and a Henry's Law Constant of about 0.0035 atm-m³/mol (Howard, 1989). CB is relatively mobile, similar to the BTEX compounds. The solubility of CB in water at 25°C is about 472 mg/L (Howard, 1989).

1,2-DCB (also known as o-DCB) is slightly volatile, with a vapor pressure of 156 mm of Hg at 25°C and a Henry's Law Constant of about 0.0012 atm-m³/mol at 20°C (Howard, 1990). It sorbs more strongly than the other chlorinated compounds discussed herein, with behavior similar to ethylbenzene or xylenes. The solubility of 1,2-DCB in water at 25°C is about 156 mg/L (Howard, 1990).

With the exception of TCE and 1,1,1-TCA, all of these compounds have been shown to be primary substrates for microbial metabolism. Simultaneous biodegradation of aliphatic,

aromatic, and alicyclic hydrocarbons has been observed. In fact, mineralization rates of hydrocarbons in mixtures, such as gasoline, may be faster than mineralization of the individual constituents as a result of cometabolic pathways (Jamison *et al.*, 1975; Perry, 1984). Moreover, during reductive dehalogenation, some of the compounds may be used as substrates/electron donors while others are used as electron acceptors.

On the basis of these physiochemical characteristics, RNA, biosparging, and groundwater extraction and treatment could all be effective options for collecting, destroying, and/or treating dissolved BTEX and chlorinated solvents at Site LF-06. Some of these options are considered less desirable after considering site-specific conditions (Section 6.2.3) and program objectives (Section 6.2.1).

6.2.3 Site-Specific Conditions

Three general categories of site-specific characteristics were considered when identifying remedial approaches for comparative evaluation as part of this demonstration. The first category was physical characteristics such as groundwater depth, hydraulic conductivity, gradient, flow direction, and soil type. The second category was the site geochemistry, or how the site contaminants are interacting with electron acceptors, microorganisms, and other site contaminants. Both of these categories influence the types of remedial technologies most appropriate for the site. The third category involved assumptions about future land use and potential receptor exposure pathways. Each of these site-specific characteristics has influenced the development of remedial alternatives included in the comparative evaluation.

6.2.3.1 Physical Characteristics

Site geology and hydrogeology have a profound effect on the transport of contaminants and the effectiveness and scope of required remedial technologies at a given site. Hydraulic conductivity is perhaps the most important aquifer parameter governing groundwater flow and contaminant transport in the subsurface. The velocity of the groundwater and dissolved contamination is directly related to the hydraulic conductivity of

the saturated zone. The estimated average advective groundwater velocity at LF-06 is 2.2 ft/day (800 ft/yr) (Section 3.3.2.4).

Although the relatively high hydraulic conductivities of the study area can result in greater plume expansion and migration, this same characteristic also can enhance the effectiveness of other remedial technologies, such as groundwater extraction, biosparging, and intrinsic remediation. For example, it should be less expensive and time-consuming to capture and treat a contaminant plume using a network of extraction wells in an area of high hydraulic conductivity because each well could envelope a larger area of influence and sustain a higher flow rate. The effectiveness of biosparging also may be increased in highly conductive and/or homogeneous aquifers because of reduced entry pressures and short-circuiting, and increased mixing of sparge air and groundwater. In addition, greater hydraulic conductivity would increase the amount of contaminant mass traveling through a biosparging network. Given a moderately high groundwater velocity, the effectiveness of natural attenuation can increase as a result of enhanced dilution and dispersion of the contaminant mass. The movement of contaminant mass within the subsurface away from the source area also can bring contaminants into contact with a larger mass of electron donors and acceptors, thereby increasing rates of biodegradation.

Like hydraulic conductivity, the organic carbon content of native phreatic zone soils can influence the effectiveness of remedial alternatives. The soils across the phreatic surface in the study area have a low organic carbon content (less than 0.06 percent), and therefore, the soils have a correspondingly low sorptive potential. However, sorptive capacity where soil TOC is greater than 0.01 percent is typically sufficient to cause a difference in the groundwater and contaminant velocities. The difference between contaminant and groundwater velocity increases the effectiveness of biodegradation in the source area because there are fresh electron acceptors flowing past the slower moving dissolved contaminant mass.

6.2.3.2 Geochemical Characteristics

To satisfy the requirements of indigenous microbial activity and RNA, the aquifer also must provide an adequate and available carbon or energy source (e.g., fuel hydrocarbon contamination), electron acceptors, essential nutrients, and proper ranges of pH, temperature, and redox potential. Data collected as part of the field work phase of this demonstration project and described in Sections 3 and 4 of this TS indicate that this site is characterized by adequate and available carbon/energy sources and electron acceptors to support measurable biodegradation of fuel hydrocarbon contamination by indigenous microorganisms. DO, nitrate, ferric iron, sulfate, and carbon dioxide represent sources of significant electron acceptor capacity for the biodegradation of organic compounds at LF-06.

The average pH in shallow site groundwater ranged between 4.3 and 6.8 standard units in November 1996, which is within to slightly below the optimal range for biodegradation of 6 to 8 standard pH units (Wiedemeier *et al.*, 1995). As pH values drop below 6 standard units, bacteria populations can be expected to decrease, which in turn may reduce the rate of hydrocarbon biodegradation. Redox potentials ranged from -300 to 284 mV in November 1996 (Figure 4.14), and suggest a groundwater environment that is both oxidizing and reducing. The redox potentials at the site suggest that aerobic biodegradation, nitrate reduction, iron (II) reduction, sulfate reduction, and methanogenesis (consistent with observed geochemical indicator trends discussed in Section 4) would reduce contaminant concentrations in groundwater. Groundwater data presented in Section 4 strongly support the conclusion that aerobic and anaerobic processes are reducing BTEX contamination given the current geochemical conditions. These same processes also appear to be acting upon chlorinated solvents, both as electron donors and electron acceptors.

Microbe addition was not considered a viable remedial approach for this site on the basis of observed geochemical trends that suggest that significant microbial activity is

likely occurring. Hydrocarbon-degrading microorganisms are ubiquitous in the subsurface, and a large number of hydrocarbon-degrading isolates (bacteria and fungi) have been discovered in different soil environments (see Wiedemeier *et al.*, 1995 and 1996a for a partial listing). Indigenous microorganisms have a distinct advantage over microorganisms injected into the subsurface to enhance biodegradation because indigenous microorganisms are well adapted to the physical and chemical conditions of the subsurface in which they reside (Goldstein *et al.*, 1985).

6.2.3.3 Potential Receptor Exposure Pathways

A pathways analysis identifies the potential human and ecological receptors that could come into contact with site-related contamination and the pathways through which these receptors might be exposed. To have a completed exposure pathway, there must be a source of contamination, a potential mechanism(s) of release, a pathway of transport to an exposure point, an exposure point, and a receptor. If any of these elements do not exist, the exposure pathway is considered incomplete, and receptors will not come into contact with site-related contamination. Evaluation of the potential long-term effectiveness of any remedial technology or remedial alternative as part of this demonstration project includes determining the potential for pathway completion. If a completed exposure pathway exists (e.g., surface water contact), potential long-term remedial options may still be sufficient to maintain exposure concentrations below regulatory action levels. Establishing site-specific, risk-based cleanup levels is beyond the scope of this TS.

Assumptions about current and future land uses at a site form the basis for identifying potential receptors, potential exposure pathways, reasonable exposure scenarios, and appropriate remediation goals. USEPA (1991) advises that the land use associated with the highest (most conservative) potential level of exposure and risk that can reasonably be expected to occur should be used to guide the identification of potential exposure pathways and to determine the level to which a site must be remediated. Because the site is near recreational facilities for a secured military Base and covered by grass and trees, Base

workers and their families are the most probable potential receptors that could be exposed to any site-related contamination.

There are two Base water supply wells located approximately 1 mile west of Site LF-06, but both of these wells are screened nearly 400 feet bgs in the confined regional aquifer. The surface water drainage south of the landfill could be another potential exposure point for human and/or ecological receptors; however, groundwater elevation data and contaminant plume configurations suggest that site groundwater flow is predominantly to the west. Several residential wells lie within 0.5 mile of Site LF-06 to the south and southeast. One of the residential wells in the area was drilled to a depth of 165 feet, but the screen is at a depth of 54 feet. Depth and casing information is unavailable for the other residential wells in the area, but the residential wells could draw from the shallow aquifer. Given the groundwater flow direction, however, it is unlikely that residential wells would be impacted by groundwater contamination from LF-06.

6.2.3.4 Remediation Goals for Shallow Groundwater

The federal MCLs as listed in 40 CFR 141-61(a) for BTEX and other VOCs are adopted as the state water quality MCLs by the MDEQ (MDEQ Office of Pollution Control, Groundwater Division, Groundwater Quality Standards, Section 3, Numerical Groundwater Standards). MCLs for compounds of potential concern detected in LF-06 groundwater are presented in Table 6.1. Although it is unlikely that groundwater from Site LF-06 would be ingested by humans because there are no current downgradient water supplies in close proximity to the site and the Base is converting to a City supply system in the near future, the state MCLs will be used to evaluate the effectiveness, implementability, and cost of remedial alternatives in this TS.

For this TS, the primary remedial objective for evaluation of remediation technologies for shallow groundwater is to reduce contaminant concentrations in groundwater to below state regulatory criteria at a downgradient sentry well. To accomplish this, remedial alternatives focus on limiting migration of dissolved contaminant concentrations exceeding

MCLs away from Site LF-06 and (possibly) towards the Base boundary. Source remediation was not considered because the source areas are not well-defined.

TABLE 6.1
GROUNDWATER QUALITY STANDARDS
LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Compound	State Maximum Contaminant Level ($\mu\text{g/L}$) ^{a/}
Benzene	5
Trichloroethylene	5
Vinyl Chloride	2
Chlorobenzene	100

^{a/} Source: MDEQ Office of Pollution Control, Groundwater Division, Groundwater Quality Standards, Section 3, Numerical Groundwater Standards.

Available data suggest that there are no completed exposure pathways involving human and ecological receptors exposed to contaminated groundwater under current conditions. Site LF-06 is part of a secured military base, so institutional controls can be incorporated to limit any future intrusive activity at the site. The required period of any groundwater and soil institutional controls associated with the selected remedial alternative is likely to expire before any anticipated future land use changes. Off-base migration of dissolved contaminants in concentrations exceeding MCLs appears unlikely, given the groundwater flow direction and observed concentrations. Also, analytical model results suggest that the contaminant plumes have reached a steady-state configuration and that significant migration of contaminant concentrations exceeding MCLs beyond the observed plume extents is unlikely.

6.2.4 Summary of Remedial Option Screening

Several remedial options have been identified and screened for use in treating the shallow groundwater at the site. Table 6.2 identifies the initial remedial technologies and

approaches considered as part of this demonstration and those retained for detailed comparative analysis. Screening was conducted systematically by considering the program objectives of the AFCEE RNA demonstration, physiochemical properties of groundwater contaminants detected at LF-06, and other site-specific characteristics such as hydrogeology, geochemistry, land use assumptions, potential receptor exposure pathways, and appropriate remediation goals. All of these factors will influence the technical effectiveness, implementation, and relative cost of technologies for remediating shallow groundwater underlying and migrating from the site. The remedial options retained for development of remedial alternatives and comparative analysis include institutional controls, natural attenuation, LTM, biosparging, air sparging, groundwater extraction, and air stripping for treatment of extracted groundwater.

6.3 BRIEF DESCRIPTION OF REMEDIAL ALTERNATIVES

This section describes how remedial technologies retained from the screening process were combined into three remedial alternatives for the study area. Sufficient information on each remedial alternative is provided to facilitate a comparative analysis of effectiveness, implementability, and cost in Section 6.4.

6.3.1 Alternative 1 - RNA and Institutional Controls with Long-Term Groundwater Monitoring

RNA is achieved when natural attenuation mechanisms bring about a reduction in the total mass of a contaminant in the soil or dissolved in groundwater. RNA results from the integration of several subsurface attenuation mechanisms that are classified as either destructive or nondestructive. Destructive attenuation mechanisms include biodegradation, abiotic oxidation, and hydrolysis. Nondestructive attenuation mechanisms include sorption, dilution (caused by dispersion and infiltration), and volatilization. In some cases,

TABLE 6.2
INITIAL TECHNICAL IMPLEMENTABILITY SCREENING OF
TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER REMEDIATION
 LF-06 RNA TS
 COLUMBUS AFB, MISSISSIPPI

General Response Action	Technology Type	Process Option	Implementability	Effectiveness	Relative Cost	Retain
Long-Term Monitoring	Periodic Groundwater Monitoring	Confirmation Wells	Many wells and monitoring points are available to confirm the progress of remediation. Sufficient space exists for additional wells.	Necessary for all remediation strategies	Low	Yes
		Point-of-Compliance Wells	Sufficient distance exists between the plume and point-of-compliance to locate several wells.	Necessary	Low	Yes
Institutional Controls	Groundwater Use Control	Land Use Control/Regulate Well Permits	The plume lies within the base boundary, and land and groundwater use are under base jurisdiction.	Necessary	Low	Yes
		Seal/Abandon Existing Wells	No production wells are known to exist in the current or predicted plume area.	Not required at this site	Low	No
		Point-of-Use Treatment	No shallow groundwater is extracted from the plume area for any use.	Low	Moderate	No
		Meetings/Newsletters	Base public relations and environmental management offices have many information avenues to workers and residents.	Necessary	Low	Yes
Containment of Plume	Hydraulic Controls	Interceptor Trench Collection	No likely receptors immediately downgradient of site. Size of plume and hydraulic conductivity of site soils favors pumping.	Moderate to High	Moderate	No
		Groundwater Extraction	Would prevent downgradient migration of dissolved contaminants, including off-site migration.	Moderate to High	Moderate	Yes
	Physical Controls	Slurry Walls/Grout Curtains	Although implementable, the technology would be costly and less effective because of high groundwater velocity and consequently large groundwater volume.	Low	High	No
		Sheet Piling	Although implementable, the technology would be costly and less effective because of high groundwater velocity and consequently large groundwater volume.	Low	High	No
	Reactive/ Semi-Permeable Barriers	Biologically Active Zones	Degradation of contaminants can be stimulated by allowing groundwater to flow through a nutrient-rich barrier. Although implementable, the technology is new and relatively costly unless concentrations are high.	Moderate	High	No

TABLE 6.2 (continued)
INITIAL TECHNICAL IMPLEMENTABILITY SCREENING OF
TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER REMEDIATION

LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

General Response Action	Technology Type	Process Option	Implementability	Effectiveness	Relative Cost	Retain
In Situ Groundwater Treatment	Biological	Oxygen and/or Nutrient-Enhanced Biodegradation (Biosparging)	Oxygen and/or nutrients are injected downgradient of plume to limit plume migration by enhancing biodegradation of BTEX, DCE, DCA, VC, CB, and/or DCB and reducing contaminant concentrations through volatilization. Implementable, and technology may enhance natural attenuation processes for most compounds. However, compounds such as TCE and 1,1,1-TCA do not biodegrade under aerobic conditions.	Moderate	Low	Yes
	Chemical/Physical	Natural Attenuation	A combination of natural biological, chemical, and physical removal mechanisms which occur to varying degrees on every site. Groundwater sampling at LF-06 indicates that this is an ongoing remediation process.	High	Low	Yes
Source Removal/ Groundwater Remediation		Air Sparging (Volatilization)	Injection of air into contaminated aquifer creating a mass transfer of contamination into air bubbles and vadose zone. Similar to biosparging in effectiveness; however, more mass is transferred than destroyed.	Moderate	Low	Yes
	Groundwater Extraction	Vertical Pumping Wells	Source area of groundwater plume is pumped by installing submersible pumps in source area wells. Limited by contaminant mass transfer rates into the groundwater; therefore, for steady-state or shrinking plumes it is comparably effective to RNA.	Moderate	Moderate	No
Aboveground Groundwater Treatment	Biological	Bioreactors	High flow rates require excessive retention times and large reactors. Volatile hydrocarbons are often volatilized in these systems.	Moderate	High	No
	Chemical/Physical	Air Stripping	Cost-effective technology for removing volatile hydrocarbons from groundwater at high flow rates. Potential permitting for air emissions.	High	Moderate	Yes
		Activated Carbon	Cost prohibitive for more concentrated hydrocarbons, and does not remove VC. Creates a carbon disposal problem.	Moderate	High (O&M)	No
		Direct Discharge to Industrial Waste Water Treatment Plant (IWWTP)	Implementable option only when an IWWTP is readily available and capable of handling BTEX, TPH, chlorinated solvent, and hydraulic loading. IWWTP not available for this site.	High	Low	No
		UV/Ozone Reactors	High flow rates require lengthy retention times and large, costly reactors.	Moderate	High	No

TABLE 6.2 (concluded)
INITIAL TECHNICAL IMPLEMENTABILITY SCREENING OF
TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER REMEDIATION

LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

General Response Action	Technology Type	Process Option	Implementability	Effectiveness	Relative Cost	Retain
Treated Groundwater Disposal	Discharge to IWWTP or Sanitary Sewer	IWWTP	Implementable option only when an IWWTP is available and capable of handling hydraulic loading. IWWTP is not available.	High	Low	No
		Sanitary Sewer	Implementable option only when access to a sanitary sewer exists and hydraulic loading is acceptable.	High	Low	Yes
	Treated Groundwater ReInjection	Vertical Injection Wells	Injection wells subject to clogging, high maintenance, and permitting.	Moderate	Moderate	No
		Injection Trenches	Requires large trenches and can be subject to injection well permitting.	Moderate	Moderate	No
Source Removal/Soil Remediation	Discharge to Surface Waters	Storm Drains	Generally requires NPDES or other discharge permit	High	Low	Yes
		Landfilling	For reasons of risk and cost reduction, in-situ methods preferable when possible. Sources are widely distributed and locations are poorly defined.	Moderate	Moderate	No
		Biological Landfarming	For reasons of risk and cost reduction, in-situ methods preferable when possible. Sources are widely distributed and locations are poorly defined.	Moderate	Moderate	No
		Thermal Desorption	For reasons of risk and cost reduction, in-situ methods preferable when possible. Sources are widely distributed and locations are poorly defined.	Moderate	High	No
	<i>In Situ</i>	Bioventing	Air injection/extraction to increase soil oxygen levels and stimulate biodegradation of fuel residuals. Sources are widely distributed and locations are poorly defined. Not a proven treatment for chlorinated solvents.	Moderate to High	Low	No
		Soil Vapor Extraction	Vapor extraction has been successfully implemented at other sites. Highly implementable in sandy soils and effective for volatiles in unsaturated soils. May be subject to air permitting. Sources are widely distributed and locations are poorly defined.	High	Low to Moderate	No
		Soil Washing	Water and/or surfactant solution are forced through zones of residual contamination to enhance contaminant partitioning into the groundwater. Most effective in homogeneous sandy soils. Sources are widely distributed and locations are poorly defined.	Low	High	No

RNA will reduce dissolved contaminant concentrations below numerical concentration goals intended to be protective of human health and the environment. As indicated by the evidence of RNA described in Section 4, these processes are occurring in the vicinity of LF-06 and will continue to reduce contaminant mass in the plume area. Moreover, most contaminant concentrations are below MCLs or only slightly above MCLs.

Results of an analytical contaminant transport model suggest that the concentrations of the groundwater contaminant plume emanating from LF-06 will drop below MCLs within, at most, 305 meters (1,000 feet) downgradient from the edge of the landfill. VC and benzene are the most likely to migrate that far, as supported by both modeled and observed results showing widespread diffused concentrations. TCE and CB are likely to migrate less far before dropping below MCLs, largely due to greater sorption relative to benzene and VC. These results also suggest that the observed conditions represent a steady-state plume, because the distances from the wells with the highest concentrations of the modeled compounds to the downgradient plume extents is at most about 1,300 feet. The observed contaminant plumes are therefore unlikely to grow more than 100 feet longer. These results are conservative because they assume the source of contamination will maintain a constant strength over time, while the sources may decrease due to weathering (loss of mass to dissolution, volatilization, and biodegradation).

Implementation of Alternative 1 would require the use of institutional controls such as land use restrictions and LTM. Land use restrictions may include placing long-term restrictions on soil excavation within the source area and long-term restrictions on groundwater well installations within and downgradient from the plume area. The intent of these restrictions would be to reduce potential receptor exposure to contaminants by legally restricting activities within areas affected by site-related contamination.

Long-term monitoring would be performed at a regular frequency and would consist of sampling a set of wells, including upgradient, source area, plume extent, and sentry wells.

For this site, it is assumed that 10 years of annual monitoring would be needed to establish that the plume is stable or shrinking and that contaminant concentrations are decreasing. The site- and alternative-specific LTM strategy is provided in Section 7. On the basis of predictive contaminant fate and transport model results (Section 6.4), it is unlikely that contaminant concentrations exceeding MDEQ groundwater MCLs would approach a potential receptor exposure point. Nevertheless, LTM is the technical mechanism used to evaluate the progress of natural attenuation processes and to ensure that remedial objectives are being met. Detection of benzene, TCE, VC, or CB in excess of their individual MDEQ MCLs at any sentry well may require additional evaluation to assess contaminant migration and to determine the probable extent of migration, or to determine if additional corrective action is necessary. In either case, land use restrictions would require reevaluation.

Public education on the selected alternative would be developed to inform Base personnel and residents of the scientific principles underlying source reduction and RNA. This education could be accomplished through public meetings, presentations, press releases, and posting of signs where appropriate. Periodic site reviews also could be conducted every year using data collected from the long-term groundwater monitoring program. The purpose of these periodic reviews would be to evaluate the extent of contamination, assess contaminant migration and attenuation through time, document the effectiveness of source removal and/or institutional controls at the site, and reevaluate the need for additional remedial actions at the site.

6.3.2 Alternative 2 - Biosparging, RNA, and Institutional Controls with Long-Term Groundwater Monitoring

This alternative is identical to Alternative 1 except that a sparging system would be used to minimize downgradient migration of dissolved contamination by placing a line of sparging wells perpendicular to the observed groundwater flow direction near the downgradient end of the contaminant plume(s). Biosparging is used to enhance the biodegradation of organic contaminants in subsurface soils and groundwater by supplying

oxygen to indigenous microbes using low-flow air injection. Some volatilization of contaminants may occur, but the biosparging system is intended to be operated at a low rate of air injection that significantly reduces emissions into the atmosphere while maximizing *in situ* biodegradation. Air sparging uses higher air flow rates to volatilize contaminants, although some biodegradation also will occur.

If it is determined that the low flow rates for a biosparging system would not be sufficient and that removal of contaminant mass would be improved by substantially increasing the air injection rate, air sparging could be promoted by simply increasing air flow rates. In this case, a SVE system may be needed to recover and treat soil vapors prior to discharge to the atmosphere. However, regardless of which system is implemented, SVE is not likely to be needed due to the low dissolved contaminant concentrations. Because no source reduction is included, biosparging/air sparging will not appreciably reduce the time required for RNA to reduce contaminant concentrations upgradient from the sparging system.

On the basis of Parsons ES' experience in the application of biosparging technology, a line of 45 vertical air injection wells should be sufficient to prevent dissolved groundwater contamination from migrating further downgradient from LF-06. Approximately 5 shallow vapor monitoring points also would be installed for measurement of the injection wells effectiveness. The conceptual design assumes that biosparging points would be 30 feet deep with 5 feet of screen between about 15 and 20 feet beneath the water table. Biosparging wells also are assumed to have an approximate radius of influence of 10 feet. To estimate the cost of remediation, it was assumed that the biosparging system would be operated for 10 years because, as with Alternative 1, it may take that long to establish the long-term concentration trends in the area upgradient of the sparge line.

As with Alternative 1, institutional controls and LTM would be required. Sentry and LTM wells would be the same as described for Alternative 1. Annual monitoring would

be performed for a total of 10 years to verify that no contaminant concentrations exceeding MCLs migrate downgradient from the sparge line.

6.3.3 Alternative 3 - Groundwater Extraction and Treatment, RNA, and Institutional Controls with Long-Term Groundwater Monitoring

Groundwater extraction at Site LF-06 could be performed for contaminant plume containment rather than sparging. Eight 10-inch groundwater extraction wells would be placed near the downgradient margin of the contaminant plume, along a line perpendicular to the observed groundwater flow direction. The groundwater extraction system will prevent contaminated groundwater from migrating downgradient from LF-06 and prevent completion of any potential receptor pathways. Given the relatively high natural groundwater velocity at the site (which will be further increased by pumping), pumping should rapidly capture much of the water within the plume. It is therefore estimated that the pumping system would only need to operate for 5 years before it can be shut down and LTM can begin.

Because groundwater extraction is not proposed for source reduction it may not appreciably reduce the predicted length of time required for RNA to complete groundwater remediation upgradient of the extraction system. If contaminant concentrations drop rapidly, the system could be shut off, but monitoring would have to continue to see if concentrations rebound after pumping ceases. In addition, because groundwater extraction potentially generates a large volume of waste requiring treatment (via air stripping) and disposal, the alternative does not comply well with the objectives of this AFCEE initiative.

As with Alternative 1, institutional controls and LTM would be required. LTM wells would be the same as described for Alternative 1. LTM should continue for an additional 5 years after pumping ceases to verify that concentrations do not rebound above MCLs and to establish plume behavior patterns created by pumping.

6.4 EVALUATION OF ALTERNATIVES

This section provides a comparative analysis of each of the remedial alternatives based on the effectiveness, implementability, and cost criteria. A summary of this evaluation is presented in Section 6.5.

6.4.1 Alternative 1 - RNA and Institutional Controls with Long-Term Groundwater Monitoring

6.4.1.1 Effectiveness

Alternative 1 is based on the effectiveness of natural processes that minimize contaminant migration and reduce contaminant mass over time, and the effectiveness of institutional controls. The effectiveness of RNA was evaluated through the analytical modeling presented in Section 5. Model results suggest that natural attenuation mechanisms are limiting contaminant migration and analysis of chemical data suggests that those mechanisms are reducing contaminant mass and toxicity. Contaminant (i.e., benzene, TCE, VC, and CB) concentrations should not exceed state MCLs at the sentry wells. Groundwater monitoring at the LTM and sentry wells will allow for continued evaluation of contaminant migration and ensure the safety of this alternative. While this alternative would not cease to be protective if the contaminant concentrations exceeding MCLs were detected in the sentry wells, such an instance would indicate that site conditions should be reevaluated.

The effectiveness of this remedial alternative requires that future intrusive site activities or construction activities within the plume area be conducted only by properly protected site workers. Reasonable land use assumptions for the plume area indicate that exposure is unlikely unless excavation or drilling activities bring groundwater or saturated soil to the surface. Long-term land use restrictions would be required to ensure that shallow groundwater is not pumped or removed for potable use within about 500 feet from the margins of the existing contaminant plume. Existing health and safety plans should be

enforced to reduce worker exposures during additional excavation or installing and monitoring additional wells.

Compliance with program goals is one component of the long-term effectiveness evaluation criterion. Alternative 1 would satisfy program objectives designed to promote RNA as a component of site remediation and to scientifically document natural processes. In addition, the alternative satisfies waste minimization goals as only limited drill cuttings would be generated during construction of new monitoring wells. This alternative also satisfies the program goal for cost effectiveness.

Apart from the administrative concerns associated with the enforcement of long-term land use restrictions and long-term groundwater monitoring programs, this remedial alternative should provide reliable, continued protection. It is assumed that dissolved contaminant concentrations will exceed state and federal criteria throughout the plume for approximately 10 years under Alternative 1. Furthermore, it is assumed that sampling will be performed every year for 10 years to demonstrate that RNA is reducing dissolved contaminant concentrations to levels below regulatory criteria and limiting plume migration.

6.4.1.2 Implementability

Alternative 1 is not technically difficult to implement. Installation of any additional LTM wells and monitoring of groundwater are standard procedures. Long-term management efforts would be required to ensure proper sampling procedures are followed. Periodic site reviews should be conducted to confirm the adequacy and completeness of LTM data and verify the effectiveness of this remediation approach. There also may be administrative concerns associated with long-term enforcement of groundwater use restrictions. Future land use within the source area may be impacted by leaving contaminated soil and groundwater in place. However, with the exception of any subsurface work at the site, the risk for Base personnel of exposure to contaminants will be limited. If required, the public and the regulators would have to be informed of the

benefits and limitations of the RNA option. Educational programs are not difficult to implement. Where the effectiveness of this option has been supported, the initial regulatory reaction to this alternative has been positive.

6.4.1.3 Cost

The cost of Alternative 1 is summarized in Table 6.3. Capital costs are limited to the construction of 4 new LTM wells and 2 new sentry wells. Included in the \$182,635 total present worth cost estimate for Alternative 1 are the costs of maintaining institutional controls and long-term groundwater monitoring at 14 LTM and sentry wells for a total of 10 years. If the dissolved contaminant concentrations at the site decrease rapidly or drop below MCLs for consecutive sampling events, then monitoring may be reduced or eliminated. Conversely, significant increases for consecutive sampling events or a significant increase in plume extent could warrant an increase in sampling frequency or implementation of another remedial alternative.

TABLE 6.3
ALTERNATIVE 1 - COST ESTIMATE
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

<u>Capital Costs</u>	<u>Cost</u>
Design/Construct 6 LTM/Sentry Wells	\$21,201
<u>Monitoring Costs (per Sampling Event)</u>	<u>Cost per Event</u>
Conduct Groundwater Sampling at 14 wells (annually for 10 years)	\$13,435
Maintain Institutional Controls/Public Education (10 years)	\$5,000
Project Management and Reporting (10 years)	\$4,747
Present Worth of Alternative 1 ^{a/}	\$182,635

^{a/} Based on an annual adjustment (discount) factor of 7 percent (USEPA, 1993).

6.4.2 Alternative 2 - Biosparging, RNA, and Institutional Controls with Long-Term Groundwater Monitoring

6.4.2.1 Effectiveness

The effectiveness of RNA and institutional controls with LTM is discussed for Alternative 1 in Section 6.4.1.1. Biosparging and sparging are established technologies for reducing contaminant concentrations and controlling plume migration. The goal of sparging would be to prevent dissolved contaminant concentrations that exceed MCLs from moving downgradient of the site. Although it is not likely to be needed, an SVE could be coupled with sparging to prevent migration of contaminated vapors from the system. It should be noted that problems such as channeling, which consists of preferential migration of injected air along specific, more permeable, flow paths rather than uniform air dispersal in the zone surrounding the injection screen, have been cited. However, the potential for significant channeling in the sandy deposits of the unconfined surficial aquifer is reduced.

Alternative 2 should provide reliable, continuous protection with little risk from temporary system failures. This alternative also complies with AFCEE program goals because RNA remains the predominant remediation method for contaminants dissolved in groundwater at the site, with sparging serving to limit plume migration. This remedial alternative, however, will result in the generation of additional contaminated soil that may require treatment and/or disposal. Furthermore, if an SVE system is installed, off-gas from the SVE system may require expensive treatment prior to atmospheric release.

6.4.2.2 Implementability

Installing and operating a biosparging system to prevent downgradient contaminant migration is more complex than Alternative 1; however, major obstacles are not anticipated. Installation of the sparging system involves standard engineering design and construction, including the installation of air injection wells, a regenerative blower system (1 high-capacity blower), electrical supply, and system integration.

Installation and operation of a biosparging system would require an increased commitment of labor hours and other resources to maintain and monitor the system. Periodic maintenance would be required for the regenerative blowers. Weekly system checks are recommended, and operating data such as injection pressures and flow rates would be manually recorded. It is estimated that the biosparging system would be operational for 10 years. In addition, an air emissions permit may need to be obtained prior to system start-up. The technical and administrative implementability concerns associated with the natural attenuation and LTM components of this remedial alternative are similar to those discussed for Alternative 1.

6.4.2.3 Cost

The estimated capital and operating costs of Alternative 2 are shown in Table 6.4. The total present worth cost of Alternative 2 is \$814,505. The cost of Alternative 2 is increased from the costs of Alternative 1 by the addition of the biosparging system, including system design, construction, operation, and maintenance. It is assumed that the biosparging system would operate for 10 years after installation. LTM is assumed to occur every year for 10 years to ensure that natural attenuation is reducing contaminant concentrations to below regulatory criteria throughout the groundwater plume during and after sparging system operation. The capital expense and annual costs for LTM and institutional controls are assumed to be the same as for Alternative 1. Should SVE be necessary, the costs will increase due to the additional equipment and monitoring that would be required.

6.4.3 Alternative 3 -Groundwater Extraction, RNA, and Institutional Controls with Long-Term Groundwater Monitoring

6.4.3.1 Effectiveness

Groundwater extraction is an established technology for controlling plume migration. The extraction of contaminated groundwater will prevent plume migration away from LF-06, thereby preventing any completion of potential exposure pathways. Simulation of

TABLE 6.4
ALTERNATIVE 2 - COST ESTIMATE
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

<u>Capital Costs</u>	<u>Cost</u>
Design/Construct 6 LTM/Sentry Wells	\$21,201
Design/Construct Biosparging System	\$234,925
<u>Operation, Maintenance, and Monitoring Costs</u>	<u>Cost per annum or event</u>
Operate and Maintain Biosparging System (10 years)	\$50,840
Annual Sparge System Report (10 years)	\$5,676
Conduct Groundwater Sampling at 14 wells (annually for 10 years)	\$13,435
Maintain Institutional Controls/Public Education (10 years)	\$5,000
Project Management and Reporting (10 years)	\$4,747
<u>Present Worth of Alternative 2</u> ^{a/}	\$814,505

^{a/} Based on an annual adjustment (discount) factor of 7 percent (USEPA, 1993).

the effect of groundwater extraction was not performed; however, the method of Javandel and Tsang (1986) was used to estimate the number of wells and the pumping rates needed to effect plume capture. Because source reduction is not occurring, remediation time is assumed to be the same as for the other remedial alternatives.

Alternative 3 should provide reliable, continuous protection for downgradient receptors. This alternative, however, does not comply well with all of the AFCOE program goals because of the generation of soil and water waste requiring treatment and disposal. This is especially true because the high hydraulic conductivity of site sediments requires relatively high pumping rates (totaling about 1,800 gallons per minute) to effect plume capture. The

high pumping rates result in a greater volume of water to treat and dispose. In addition, contaminants are not destroyed, but are instead transferred to another phase that may require further treatment. As with Alternatives 1 and 2, this alternative would rely on RNA with LTM and institutional controls to remediate the contaminated groundwater once the extraction system is shut down.

6.4.3.2 Implementability

Groundwater extraction would be labor intensive and expensive to implement. The option would require additional site investigation, design and engineering, installation, and a weekly commitment to operation and maintenance of the extraction and air stripper systems. An air emissions permit may need to be obtained for the air stripper prior to system start-up. A permit also may be needed for disposal of treated groundwater. The technical and administrative implementability concerns associated with the RNA, LTM, and institutional controls of this remedial alternative are similar to those discussed for Alternatives 1 and 2.

6.4.3.3 Cost

The estimated capital and operating costs of Alternative 3 are shown in Table 6.5. The total present-worth cost of Alternative 3 is \$849,348. Despite the shorter operating time frame, the cost of Alternative 3 is comparable to the costs of Alternative 2 because it is more costly to design, install, operate, and maintain the groundwater extraction system. However, the cost could be significantly higher if off-gas treatment for the air stripper is required, if the system has to run for more than 5 years, or if treated groundwater cannot be easily disposed (e.g., discharged to a storm sewer). The annual costs for LTM and institutional controls are assumed to be the same as for Alternatives 1 and/or 2. The resulting present-worth cost for LTM and institutional controls are the same as for Alternative 1 because it is assumed that the groundwater extraction system merely contains the contaminant plume without treating the source, and therefore, will operate for the same length of time.

TABLE 6.5
ALTERNATIVE 3 - COST ESTIMATE
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

<u>Capital Costs</u>	<u>Cost</u>
Design/Construct 6 LTM/Sentry Wells	\$21,201
Design/Construct/Install Groundwater Extraction and Treatment System	\$424,507
<u>Operation, Maintenance, and Monitoring Costs</u>	<u>Cost per annum or event</u>
Conduct Groundwater Sampling at 14 wells (annually for 10 years)	\$13,435
Maintain Groundwater Extraction System (5 years)	\$58,340
Maintain Institutional Controls/Public Education (10 years)	\$5,000
Project Management and Reporting (10 years)	\$4,747
<u>Present Worth of Alternative 3 ^{a/}</u>	\$849,348

^{a/} Based on an annual adjustment (discount) factor of 7 percent (USEPA, 1993).

6.5 RECOMMENDED REMEDIAL APPROACH

Three remedial alternatives have been evaluated for remediation of the shallow groundwater at the study area. Components of the alternatives evaluated include biosparging, groundwater extraction with *ex-situ* treatment, RNA with LTM of groundwater, and institutional controls. Table 6.6 summarizes the results of the evaluation based upon effectiveness, implementability, and cost criteria. Owing to the low contaminant concentrations and the high cost of engineered alternatives, the Air Force recommends Alternative 1 as the most cost-effective option for risk reduction at the study area.

All three alternatives make use of natural attenuation mechanisms to reduce plume migration and toxicity, although Alternative 3 relies more on capture of the plume with the

TABLE 6.6
SUMMARY OF REMEDIAL ALTERNATIVES EVALUATION
FOR GROUNDWATER REMEDIATION

SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Remedial Alternative	Effectiveness	Implementability	Present-Worth Cost Estimate
Alternative 1			
- Natural Attenuation - Long-Term Monitoring - Institutional Controls	Contaminant mass, volume, and toxicity will be significantly reduced and plume is unlikely to spread. MCLs are not likely to be exceeded at sentry wells.	Readily implementable. Long-term management, groundwater use controls, and monitoring required for an estimated 10 years. If MCLs are exceeded at sentry wells, additional remedial work may be required.	\$179,516
Alternative 2			
- Sparging - Natural Attenuation - Long-Term Monitoring - Institutional Controls	Similar to Alternative 1, with the addition of biosparging system. Contaminant mass, volume, and toxicity would not be reduced more rapidly than in Alternative 1. SVE system may be needed to treat contaminated vapors forced into soil from sparging activities.	Readily implementable. Installation of biosparging/SVE system should present no problems. Biosparging estimated to continue for 10 years. Long-term management, groundwater controls, and monitoring required for an estimated 10 years. If MCLs are exceeded at sentry wells, additional remedial work may be required.	\$814,505
Alternative 3			
- Groundwater Extraction - Natural Attenuation - Long-Term Monitoring - Institutional Controls	Similar to Alternative 1, with the addition of a groundwater extraction system. Contaminant mass, volume, and toxicity will not be reduced more rapidly than in Alternative 1; however, migration of dissolved contaminants downgradient from the site will be prevented.	Readily implementable. Installation and operation of groundwater extraction system will be costly and labor intensive. Groundwater extraction estimated to continue for 5 years. Long-term management, groundwater controls, and monitoring required for an estimated 10 years. If MCLs are exceeded at sentry wells, additional remedial work may be required.	\$846,229

extraction system. In addition, Alternatives 2 and 3 would use active *in situ* and *ex situ* techniques to limit contaminant migration. Implementation of Alternatives 2 and 3 would not substantially decrease the time frame for remediation, but both alternatives would require greater capital expenditures. Alternatives 2 and 3 are considered less favorable because in part they simply transfer contamination to a different medium rather than reducing contaminants to innocuous byproducts.

All three remedial alternatives are implementable and effectively reduce potential contaminant migration and toxicity in the groundwater. All three alternatives should be acceptable to the public and regulatory agencies because they are protective of human health and the environment and reduce groundwater contamination; however, none of the three alternatives addresses soil contamination. Implementation of Alternative 1, or any of the three alternatives will require land and groundwater use controls to be enforced. Groundwater monitoring would be required for the respective projected cleanup periods.

The 10-year remediation time for Alternative 1 is considered to be conservative because the plume is likely to be stable and because many of the contaminant concentrations are only slightly above MCLs. Uncertainties about the nature and location of the contaminant sources means that site conditions could change during the LTM period, and that additional contaminant mass could unexpectedly enter groundwater. However, this potential drawback would apply to all alternatives and would require reevaluation in all cases. The proposed LTM period is consistent with federal recommendations that proposed or implemented remedial activities at a site should not exceed 30 years in duration (USEPA, 1988), and even if site conditions require a change in the remedial strategy it is unlikely that this time limit would be exceeded.

The final evaluation criterion used to compare each of the remedial alternatives was cost; the additional costs of Alternatives 2 and 3 do not justify the slightly reduced risk resulting from plume containment. Future exposure to potential receptors at the site will be minimized by land use restrictions and by the low contaminant concentrations. Access

to the Base (and hence the site) is controlled by Base security. Alternative 1 will reduce the level of contamination and maintain the necessary degree of protection to potential receptors at or downgradient from the site, and is the recommended remedial alternative for shallow groundwater at LF-06. A LTM plan for groundwater, including a generic SAP, is provided in Section 7.

SECTION 7

LONG-TERM MONITORING PLAN

7.1 OVERVIEW

In keeping with the requirements of the recommended remedial alternative for LF-06 at Columbus AFB (RNA with institutional controls and LTM), a long-term groundwater monitoring plan has been developed. The purpose of this component of the suggested remedial alternative for the site is to assess site conditions over time, confirm the effectiveness of natural processes at reducing contaminant mass and minimizing dissolved contaminant migration, assess compliance with regulatory cleanup goals, and evaluate the need for additional remediation.

The LTM plan consists of identifying the location of two separate groundwater monitoring networks and developing a groundwater sampling and analysis strategy to demonstrate attainment of site-specific remediation goals and to verify the predictions of the model developed for LF-06. The strategy described in this section is designed to monitor dissolved contaminant migration over time and to verify that RNA is occurring at rates sufficient to protect potential receptors. In the event that data collected under this LTM program indicate that natural processes are insufficient to protect human health and the environment, contingency controls to augment the beneficial effects of RNA would be necessary.

7.2 MONITORING NETWORKS

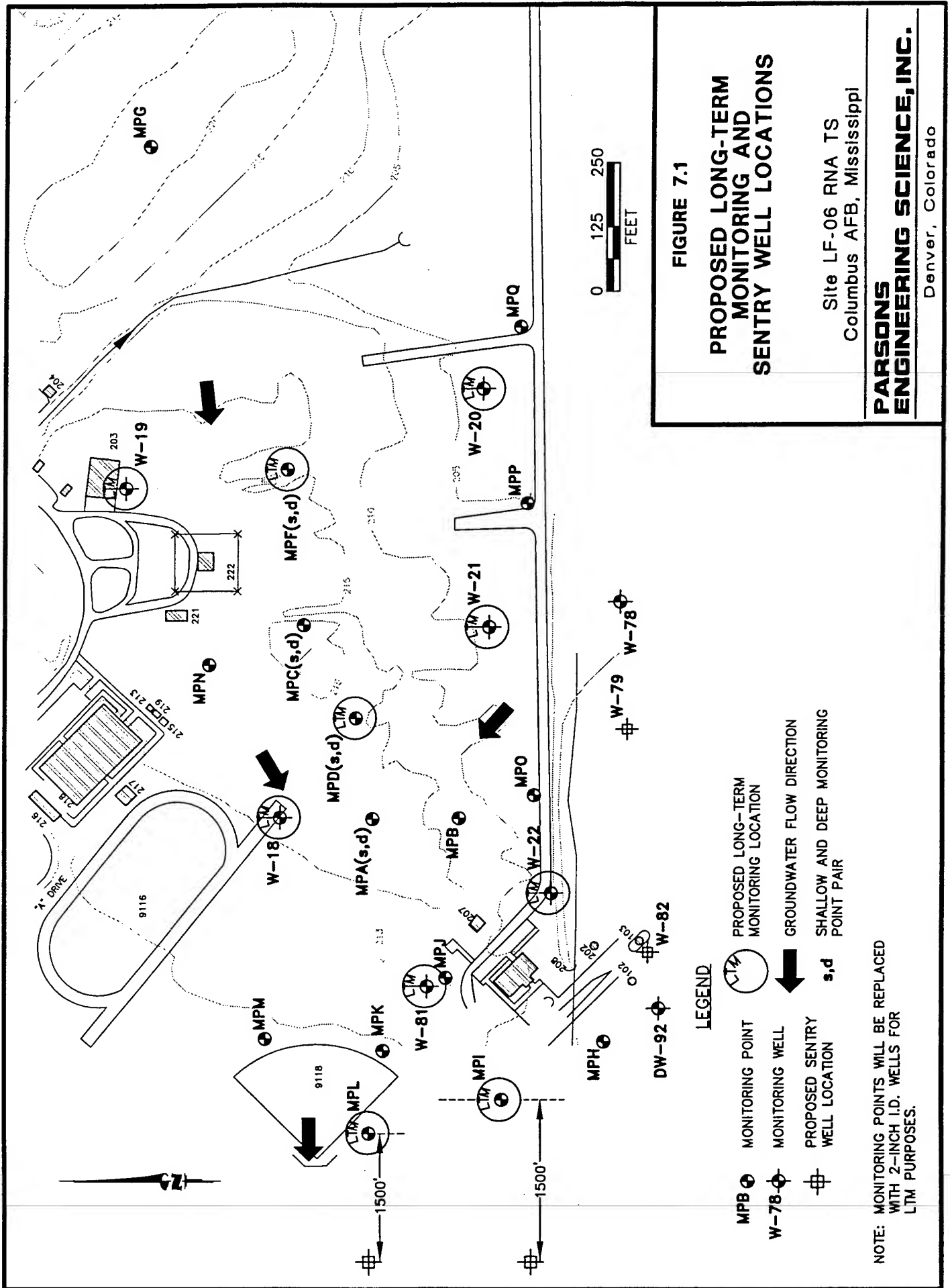
Two separate sets of wells will be utilized at the site as part of the LTM component of the remedial alternative. The first set will consist of ten LTM wells located in, upgradient from, and downgradient from the observed contaminant plume to verify that natural

attenuation is occurring at rates sufficient to minimize plume expansion and reduce both dissolved benzene and chlorinated solvent concentrations. This network of wells will consist of monitoring wells screened across the water table (shallow wells) to provide short-term confirmation of the effectiveness of natural attenuation. The second set of wells will consist of four sentry wells: two at locations along a line perpendicular to the general direction of groundwater flow, approximately 1,500 feet west of monitoring points MPL and MPI, and the other two between the site and the southern base boundary. The purpose of the sentry wells is to verify that no benzene, chlorobenzene, TCE, or vinyl chloride concentrations migrate beyond the area under institutional control. Conservative model results suggest that none of the contaminants of concern should reach the sentry wells at concentrations exceeding state criteria. The proposed LTM and sentry well locations are presented on Figure 7.1

7.2.1 Long-Term Monitoring Wells

At ten locations, groundwater wells within, upgradient from, and downgradient from the current BTEX plume will be used to monitor the effectiveness of RNA in reducing total contaminant mass and minimizing contaminant migration at LF-06. Of the ten wells proposed for the LTM network, six (W-18, W-19, W-20, W-21, W-22, and W-81) were installed during previous investigations. The remaining four wells would be installed upon implementation of this plan. Figure 7.1 identifies the proposed locations for wells to be used for LTM. This well network will supplement the four proposed sentry wells (see Section 7.2.2) to provide evidence of continuing RNA and to allow additional response time if site conditions change.

Existing well W-19 is proposed for monitoring the background groundwater quality in the shallow portion of the surficial aquifer. In addition, existing well W-20 is proposed to monitor background groundwater quality in the southern portion of the site. Monitoring wells are proposed to replace monitoring points MPF(s) and MPD(s) to monitor the shallow groundwater at the largest suspected source area and immediately downgradient



from this source area along the centerline of the contaminant plume, respectively. The two existing monitoring wells W-18 and W-21 are included in the LTM plan because both wells also are located in suspected source areas for groundwater contamination. Typically, downgradient wells are installed within both the anaerobic and aerobic treatment zones; however, because the aerobic treatment zone is difficult to define, monitoring will occur at the downgradient wells with observed contaminant concentrations that exceed state criteria. Therefore, existing monitoring wells W-22 and W-81 are proposed to be monitored along with a pair of wells that will replace monitoring points MPL and MPI. The remaining existing wells (W-20, W-78, and DW-92) would not be used for LTM because they are not in the direct flow path downgradient from the any of the suspected source areas.

The four new LTM monitoring wells will have 10-foot screened intervals. Shallow wells will be screened across the water table with approximately 8 feet of the 10-foot screen positioned below the water table. However, during the installation of new LTM wells it would be necessary to screen wells across the actual water table (15 to 20 feet bgs) rather than the perched water table [observed at monitoring point MPF(s) and MPD(s)]. Sampling frequency and analytical parameters to be monitored are discussed in Section 7.3.

7.2.2 Sentry Wells

Four sentry monitoring wells are proposed for monitoring at the site (Figure 7.1). Two are recommended for installation approximately 1,500 feet (i.e., two years of travel time at the estimated average groundwater velocity) downgradient from the current leading edge of the contaminant plume. The sentry wells are more than 2,500 feet from the western Base boundary. These locations, however, should be considered tentative because of numerous roads and underground utility corridors. The other two sentry locations will use existing wells W-82 and W-79. These locations have been selected to confirm that the direction of plume migration does not shift toward the base boundary. It is recommended that the sentry well locations be finalized upon implementation of this plan.

The purpose of sentry wells is to verify that no contaminated groundwater exceeding state criteria migrates beyond the area under institutional control. Although model results strongly suggest that the contaminant plume will not migrate beyond this area at concentrations exceeding chemical-specific state MCLs (Table 6.1), these sentry wells are the technical mechanisms used to demonstrate protection of human health and the environment and compliance with site-specific numerical RAOs. These wells will be installed and monitored to assure that the selected remedy is providing the anticipated level of risk reduction and remediation at the site. Sampling frequency and analytical parameters to be monitored are discussed in Section 7.3.

As with the LTM wells, the sentry wells will be screened in the same hydrogeologic units as the contaminant plume. Data presented in this report concerning the nature and extent of contamination at the site suggest that a 10-foot screen with approximately 8 feet of screen below the groundwater surface will be sufficient to intercept the dissolved contaminant plume in the shallow groundwater at this site.

7.3 GROUNDWATER SAMPLING

To ensure that sufficient contaminant removal is occurring at LF-06 to meet site RAOs, the long-term groundwater monitoring plan includes a sampling and analysis plan (SAP). Groundwater samples will be collected and analyzed from LTM and sentry wells to verify that natural processes are effectively reducing contaminant mass and mobility. Reductions in toxicity will be implied by mass reduction. The SAP also is aimed at assuring that RNA can achieve regulatory action levels for dissolved contaminants of concern.

7.3.1 Analytical Protocol

All LTM and sentry wells in the LTM program will be sampled and analyzed to determine compliance with chemical-specific remediation goals and to verify the effectiveness of RNA at the site. Water level measurements will be made during each sampling event. Groundwater samples from the LTM and sentry wells will be analyzed for the parameters listed in Tables 7.1 and 7.2, respectively. A site-specific groundwater SAP should be prepared prior to initiating the LTM program.

7.3.2 Sampling Frequency

Each of the 13 LTM and sentry wells will be sampled annually for 10 years. Thereafter, review meetings could be scheduled to determine future LTM frequency. For example, if LTM demonstrates the effectiveness of the proposed remedial alternative at this site, the sampling frequency could be reduced to once every two years or sampling could be eliminated. Conversely, if the data collected at any time during the monitoring period indicate the need for additional remedial activities at the site as a result of significant plume expansion or imminent pathway completion, the sampling frequency should be adjusted accordingly.

TABLE 7.1
LONG-TERM MONITORING ANALYTICAL PROTOCOL
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Analyte	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Ferrous Iron (Fe ²⁺)	Colorimetric A3500-Fe D	Field only	Elevated ferrous iron concentrations may be indicative of the anaerobic biodegradation process of iron reduction	Annually for 10 Years	Collect 100 mL of water in a glass container; acidify with hydrochloric acid per method	Field
Ferrous Iron (Fe ²⁺)	Colorimetric HACH 25140-25	Alternate method; field only	Same as above.	Annually for 10 Years	Collect 100 mL of water in a glass container	Field
Temperature	E170.1	Field only	Metabolism rates for microorganisms depend on temperature	Annually for 10 Years	N/A	Field
Dissolved Oxygen	Dissolved oxygen meter	Refer to Method A4500 for a comparable laboratory procedure	Concentrations less than 1 mg/L generally indicate an anaerobic pathway	Annually for 10 Years	Collect 300 mL of water in biochemical oxygen demand bottles; analyze immediately; alternately, measure dissolved oxygen in situ	Field
pH	E150.1/SW9040, direct reading meter	Protocols/Handbook methods ^a	Aerobic and anaerobic processes are pH-sensitive	Annually for 10 Years	Collect 100-250 mL of water in a glass or plastic container; analyze immediately	Field
Conductivity	E120.1/SW9050, direct reading meter	Protocols/Handbook methods	General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system	Annually for 10 Years	Collect 100-250 mL of water in a glass or plastic container	Field
Nitrate (NO ₃ ⁻)	IC method E300 or method SW9056; colorimetric, method E353.2	Method E300 is a Handbook method; method SW9056 is an equivalent USEPA procedure	Electron acceptor for microbial respiration if oxygen is depleted	Annually for 10 Years	Collect up to 40 mL of water in a glass or plastic container; cool to 4°C; analyze within 48 hours	Fixed-base
Ammonium (NH ₄ ⁺)	Colorimetric CHEMetrics K-1510	Field only	Confirm nitrogen fixation and/or nitrate reduction	Annually for 10 Years	Collect 100-250 mL of water in a glass or plastic container; analyze immediately	Field

TABLE 7.1 (concluded)
LONG-TERM MONITORING ANALYTICAL PROTOCOL
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Analyte	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Sulfate (SO_4^{2-})	IC method E300 or method SW9056 or Hach SulfatVer 4 method	Method E300 is a Handbook method; method SW9056 is an equivalent procedure. Hach method is photometric	Electron acceptor for anaerobic microbial respiration	Annually for 10 Years	Collect up to 40 mL of water in a glass or plastic container; cool to 4°C	Fixed-base or field (for Hach method)
Redox potential	A2580 B	Measurements are made with electrodes; results are displayed on a meter; samples should be protected from exposure to atmospheric oxygen	The redox potential of groundwater influences and is influenced by biologically mediated reactions; the redox potential of groundwater may range from more than 200 mV to less than -400 mV	Annually for 10 Years	Collect 100–250 mL of water in a glass container, filling container from bottom; analyze immediately	Field
Methane, Ethane, and Ethene	RSKSOP-114 modified to analyze water samples for methane by headspace sampling with dual thermal conductivity and flame ionization detection.	Method published and used by the USEPA Natural Risk Management Research Laboratory	The presence of methane suggests BTEX degradation via an anaerobic pathway utilizing carbon dioxide (carbonate) as the electron acceptor (methanogenesis). The presence of ethane and ethene suggest that reductive dehalogenation of vinyl chloride is occurring.	Annually for 10 Years	Collect water samples in 40 mL volatile organic analysis (VOA) vials with butyl gray/Teflon-lined caps (zero headspace); cool to 4°C	Fixed-base
Aromatic and chlorinated hydrocarbons (BTEX, TMB isomers, and chlorinated compounds)	SW8260A	Handbook method; analysis may be extended to higher molecular weight alkylbenzenes	Method of analysis for BTEX and chlorinated solvents, which are the primary target analytes for monitoring natural attenuation; concentrations of benzene, chlorobenzene, TCE and vinyl chloride must also be measured for regulatory compliance	Annually for 10 Years	Collect water samples in a 40 mL VOA vial with zero headspace; cool to 4°C; add sulfuric acid to pH ≤ 2	Fixed-base

a/ Analytical methods from the Air Force protocol document and the AFCEE Handbook are presented by Wiedemeier *et al.* (1995).

TABLE 7.2
POINT-OF-COMPLIANCE MONITORING ANALYTICAL PROTOCOL
SITE LF-06 RNA TS
COLUMBUS AFB, MISSISSIPPI

Analyte	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Temperature	E170.1	Field only	Well purging	Annually for 10 Years	N/A	Field
Dissolved Oxygen	Dissolved oxygen meter	Refer to method A4500 for a comparable laboratory procedure	Concentrations less than 1 mg/L generally indicate an anaerobic pathway	Annually for 10 Years	Collect 300 mL of water in biochemical oxygen demand bottles; analyze immediately; alternately, measure dissolved oxygen in situ	Field
pH	E150.1/SW9040, direct reading meter	Protocols/Handbook methods ^{a/}	Aerobic and anaerobic processes are pH-sensitive	Annually for 10 Years	Collect 100–250 mL of water in a glass or plastic container; analyze immediately	Field
Conductivity	E120.1/SW9050, direct reading meter	Protocols/Handbook methods	General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system	Annually for 10 Years	Collect 100–250 mL of water in a glass or plastic container	Field
Aromatic and chlorinated hydrocarbons (BTX, TMB isomers, and chlorinated compounds)	SW8260A	Handbook method; analysis may be extended to higher molecular weight alkylbenzenes	Method of analysis for BTEX and chlorinated solvents, which are the primary target analytes for monitoring natural attenuation; concentrations of benzene, chlorobenzene, TCE and vinyl chloride must also be measured for regulatory compliance	Annually for 10 Years	Collect water samples in a 40 mL VOA vial with zero headspace; cool to 4°C; add sulfuric acid to pH ≤2	Fixed-base

a/ Analytical methods from the Air Force protocol document and the AFCEE Handbook are presented by Wiedemeier *et al.* (1995).

SECTION 8

CONCLUSIONS AND RECOMMENDATIONS

This report presents the results of a TS conducted to evaluate RNA of groundwater contaminated with fuel hydrocarbons and chlorinated solvents at Site LF-06, Columbus AFB, Mississippi. Specifically, analytical models were used in conjunction with site-specific geologic, hydrologic, and laboratory analytical data to evaluate the migration and biodegradation of fuel compounds and solvents dissolved in groundwater. To obtain the data necessary for the RNA demonstration, Parsons ES collected and analyzed soil and groundwater samples from the site.

Numerous fuel hydrocarbon compounds and chlorinated solvents have been detected in site groundwater. However, only benzene, TCE, VC, and CB were present in concentrations exceeding MCLs in November 1996. Moreover, of these latter compounds, only CB was detected at a concentration greater than 23 µg/L. In the case of CB, the highest concentration (200 µg/L) was detected in a monitoring point that was screened in a perched zone of saturation immediately adjacent to a disposal trench. In a monitoring point screened in the aquifer beneath that zone, the CB concentration was well below the MCL of 100 µg/L. These relatively low concentrations suggest that the sources of contamination are limited in dimension and mass. The low concentrations also make it difficult to pinpoint source areas, except in the case of CB discussed above.

Geochemical data provided one line of evidence used to document RNA at LF-06. Comparison of BTEX, chlorinated solvent, electron acceptor, and biodegradation byproduct isopleth maps for groundwater at Site LF-06 provides strong geochemical evidence of fuel and chlorinated solvent biodegradation. Geochemical data strongly

suggest that biodegradation of fuel hydrocarbons and other organic matter (e.g., native organic matter and landfill leachate) is occurring at the site via aerobic respiration and the anaerobic processes of denitrification, iron reduction, sulfate reduction, nitrogen fixation, and methanogenesis. Evidence also strongly suggests that some of the chlorinated solvents are being used as electron acceptors as the other compounds are consumed as electron donors/substrates. This process is known as reductive dehalogenation. Rates of biodegradation were estimated from observed contaminant concentrations and the method of Buscheck and Alcantar (1995).

Historical contaminant concentration data provide a second line of evidence for RNA. Specifically, these data suggest that contaminant concentrations have remained relatively stable over time, with minor fluctuations that are likely the result of varied sampling methods and analytical methods, as well as seasonal fluctuations due to changing hydrogeologic conditions. These data also suggest that the plume is relatively stable, as concentrations at some of the wells would have changed more noticeably over time if the plume were continuing to expand.

Site-specific geologic, hydrologic, and chemical data were then used in the analytical groundwater model to simulate the effects of advection, dispersion, sorption, and biodegradation on the fate and transport of the dissolved contaminants. Site-specific data were used for model implementation. Model parameters that could not be obtained from existing site data were estimated using widely accepted literature values for aquifer materials similar to those found at the site. Conservative aquifer parameters were used to construct the model for this site. Therefore, the model results presented herein represent conservative predictions of groundwater contaminant plume fate and transport. Results of compound-specific, one-dimensional analytical models suggest that the contaminant plumes will remain stable, even if sources persist at levels that produced the highest observed concentrations for each contaminant. This complements the historical contaminant data, which also suggest that the plumes are stable.

The results of this study suggest that RNA of dissolved hydrocarbons is occurring at Site LF-06. Given that the models predict no impact to known receptors, the recommended remedial alternative for site groundwater impacted by fuel hydrocarbons and chlorinated hydrocarbons includes RNA, institutional controls, and LTM. Active source area remediation is not practical because the source areas are not well defined and probably not very large (i.e., they are low-mass sources). In addition, the low concentrations of contaminants detected in site groundwater and the apparent stabilization of the plume make it unlikely that any downgradient receptors will be impacted. Engineered groundwater remedial alternatives will not be cost-effective because a relatively small mass of contaminants will be removed for a relatively high cost.

Because the site is located on an active, secured installation, all future site activities will occur under the direct supervision of the Air Force. The estimated rates of biodegradation, when coupled with sorption, dispersion, and dilution, should be more than sufficient to reduce and maintain dissolved contaminant concentrations at levels below current regulatory standards long before potential downgradient receptors could be adversely affected. Construction activities in the plume area, and groundwater use in and downgradient from the plume area, should be restricted until groundwater contaminant concentrations decrease below state MCLs for benzene, TCE, VC, and CB.

To verify the results of the modeling effort, and to ensure that RNA is occurring at rates sufficient to protect potential downgradient receptors, groundwater from ten LTM wells should be sampled and analyzed for the parameters listed in Table 7.1. In addition, four sentry wells downgradient from the BTEX plume should be sampled for the parameters listed in Table 7.2. Figure 7.1 shows suggested locations for the LTM and sentry wells. Each of the LTM and sentry wells will be sampled annually for 10 years. After this time, the results from LTM should be evaluated to determine whether sampling will cease, will decrease in frequency, or will continue on an annual basis. If dissolved contaminant concentrations in groundwater collected from the sentry wells exceed regulatory criteria, or

if monitoring data suggest that contaminant concentrations are increasing due to an as yet unidentified source, additional evaluation or corrective action may be necessary at this site. In addition, if contaminant concentrations remain relatively stable and show no decreasing trend, additional work could be needed as well.

SECTION 9

REFERENCES

- Altenschmidt, U. and Fuchs, G., 1991, Anaerobic degradation of toluene in denitrifying *Pseudomonas* sp.: Indication for toluene methylhydroxylation and benzoyl-CoA as central aromatic intermediate: *Arch. Microbial.*, vol. 156, p. 152-158.
- Alvarez, P.J.J., and Vogel, T.M., 1991, Substrate interactions of benzene, toluene, and para-xylene during microbial degradation by pure cultures and mixed culture aquifer slurries: *Applied Environmental Microbiology*, vol. 57, p. 2981-2985.
- Alvarez-Cohen, L.M. and McCarty, P.L., 1991a, Effects of toxicity, aeration, and reductant supply on trichloroethylene transformation by a mixed methanotrophic culture: *Appl. Environ. Microbiol.*, vol. 57, no. 1, p. 228-235.
- Alvarez-Cohen, L.M., and McCarty, P.L., 1991b, Product toxicity and cometabolic competitive inhibition modeling of chloroform and trichloroethylene transformation by methanotrophic resting cells: *Appl. Environ. Microbiol.*, vol. 57, no. 4, p. 1031-1037.
- Arciero, D., Vannelli, T., Logan, M., and Hooper, A.B., 1989, Degradation of trichloroethylene by the ammonia-oxidizing bacterium *Nitrosomonas europaea*: *Biochem. Biophys. Res. Commun.*, vol. 159, p. 640-643.
- Ashworth, R.A., Howe, G.B., Mullins, M.E., and Rogers, T.N., 1988, Air-water partitioning coefficients of organics in dilute aqueous solutions. *Journal of Hazardous Materials*, 18:25-36.

- Atlas, R.M., 1981, Microbial degradation of petroleum hydrocarbons - an environmental perspective: Microbiological Reviews, vol. 45, no. 1, p. 180-209.
- Atlas, R.M., 1984, Petroleum Microbiology: Macmillan Publishing Company, New York.
- Atlas, R.M., 1988, Microbiology - Fundamentals and Applications: Macmillan Publishing Company, New York.
- Baedecker, M.J., Siegel, D.I., Bennett, P.C., Cozzarelli, I.M., 1988, The fate and effects of crude oil in a shallow aquifer: I. The distribution of chemical species and geochemical facies, In: G.E. Mallard, and S.E. Ragone, editors, U.S. Geological Survey Toxic Substances Hydrology Program, Proceedings of the Technical Meeting, Phoenix, Arizona, September 26-30, 1988: U.S. Geological Survey Water-Resources Investigations Report 88-42320, p. 29-22.
- Baedecker, M.J., and Cozzarelli, I.M., 1991, Geochemical modeling of organic degradation reactions in an Aquifer contaminated with Crude Oil: U.S. Geological Survey Water-Resources Investigations Report 91-4034. Reston, VA. p 627-632.
- Ball, H.A., Reinhard, M., and McCarty, P.L., 1991, Biotransformation of monoaromatic hydrocarbons under anoxic conditions, In: In Situ Bioreclamation, Applications and Investigations for Hydrocarbon and Contaminated Site Remediation. Eds. R.E. Hinchee and R.F. Olfenbuttel. Butterworth-Heinemann. Boston, MA. p. 458-463.
- Barker, J.F., Patrick, G.C., and Major, D., 1987, Natural attenuation of aromatic hydrocarbons in a shallow sand aquifer: Ground Water Monitoring Review, Winter, 1987, p. 64-71.
- Bartha, R., 1986, Biotechnology of petroleum pollutant biodegradation: Microbial Ecology, vol. 12, p. 155-172.

- Bauman, B., 1991, Biodegradation research of the American Petroleum Institute. Presented at: In Situ Bioreclamation: Application and Investigation for Hydrocarbons and Contaminated Site Remediation. San Diego, CA. March 19-21, 1991.
- Bear, J., 1979, Hydraulics of Groundwater. McGraw-Hill, Inc., New York, New York, 569p.
- Beller, H.R. Reinhard, M., and Grbic-Galic, D., 1992, Metabolic byproducts of anaerobic toluene degradation by sulfate-reducing enrichment cultures: Appl. Environ. Microbiol., vol. 58, p. 3192-3195.
- Bohon, R.L., and Claussen, W.F., 1951, The solubility of aromatic hydrocarbons in water: Journal of American Chemical Society, vol. 73, no. 4, p.1571-1578.
- Borden, R.C., 1991, Simulation of enhanced in situ bioremediation of petroleum hydrocarbons. In: In Situ bioreclamation: Application and Investigation for Hydrocarbons and contaminated Site Remediation. Eds., R.E. Hincbee and R. F. Olfenbittel. Butterworth-Heinemann. p. 529-534.
- Bouwer, E.J., 1992, Bioremediation of Subsurface Contaminants, In: Mitchell, R., ed.: Environmental Microbiology. Wiley-Liss, New York, New York.
- Bouwer, E.J., 1994, Bioremediation of chlorinated solvents using alternate electron acceptors: In: Handbook of Bioremediation. Lewis Publishers. Boca Raton, FL.
- Bouwer, E.J., Rittman, B.E., and McCarty, P.L., 1981, Anaerobic degradation of halogenated 1- and 2-carbon organic compounds: Environ. Sci. Technol., vol. 15, no. 5, p. 596-599.
- Bouwer, E.J. and Wright, J.P., 1988, Transformations of trace halogenated aliphatics in anoxic biofilm columns: J. Contam. Hydrol., vol. 2, p. 155-169.

- Bouwer, H., 1989, The Bouwer and Rice slug test - an update: *Ground Water*, 27(3), p. 304-309.
- Bouwer, H., and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: *Water Resources Research*, 12(3), p. 423-428.
- Bradley, P.M., and Chapelle, F.H., 1996, Anaerobic mineralization of vinyl chloride in Fe(III)-reducing aquifer sediments: *Environmental Science and Technology*, vol. 40, p. 2084 - 2086.
- Brown, R.A., Dey, J.C. and McFarland, W.E., 1991, Integrated site remediation combining groundwater treatment, soil vapor extraction, and bioremediation, In: *In Situ Bioreclamation: Application and Investigation for Hydrocarbons and Contaminated Site Remediation*. Eds., R.E. Hinchey and R. F. Olfenbuttel. Butterworth-Heinemann. p. 444-449.
- Buscheck, T.E., O'Reilly, K.T., and Nelson, S.N., 1993, Evaluation of Intrinsic Bioremediation at Field Sites: *Proceedings, Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Restoration*, pp. 367-381. National Ground Water Association/API, Houston, TX.
- Buscheck, T. E., and Alcantar, C. M., 1995, Regression Techniques and Analytical Solutions to Demonstrate Intrinsic Bioremediation. In: *Proceedings of the 1995 Battelle International Symposium on In Situ and On-Site Bioreclamation*, April 1995.
- Butler, B.J., and Barker, J.F., 1996, Chemical and microbiological transformation and degradation of chlorinated solvent compounds, In: Pankow, J.F., and Cherry, J.A., eds., *Dense Chlorinated Solvents and Other DNAPLs in Groundwater: History, Behavior, and Remediation*: Waterloo Press, Waterloo, Ontario, p. 267-312.

- CH2M Hill, 1989, Air Force Installation Restoration Program Remedial Investigation Report, Columbus Air Force Base, Mississippi, prepared for Headquarters Air Training Command/DDEV, December.
- CH2M Hill, 1995, Air Force Installation Restoration Program Site Inspection Report, Final, Columbus Air Force Base, Mississippi, prepared for Headquarters Air Education and Training Command/CEVR, June 1995.
- Chapelle, F.H., 1993, Ground-water Microbiology and Geochemistry. John Wiley and Sons, Inc., New York, NY.
- Chapelle, F.H., 1994, Assessing the Efficiency of Intrinsic Bioremediation, in Proceedings of the Symposium on Intrinsic Bioremediation of Ground Water, August 30 - September 1, 1994: US Environmental Protection Agency, p. 171.
- Chiang, C.Y., Salanitro, H.P., Chai, E.Y., Colthart, H.D., and Klein, C.L., 1989, Aerobic biodegradation of benzene, toluene, and xylene in a sandy aquifer - data analysis and computer modeling: Ground Water, vol. 27, no. 6, p. 823-834.
- Cline, P.V., and Delfino, J.J., 1989, Transformation kinetics of 1,1,1-trichloroethane to the stable product 1,1-dichloroethene, In: Biohazards of Drinking Water Treatment. Lewis Publishers, Inc. Chelsea, MI. p. 47-56.
- Cozzarelli, I.M., Eganhouse, R.P., and Baedecker, M.J., 1990, Transformation of monoaromatic hydrocarbons to organic acids in anoxic ground water environment: Environmental and Geological Water Science, vol. 16.
- Davis, J.W., and Carpenter, C.L., 1990, Aerobic biodegradation of vinyl chloride in groundwater samples: Applied and Environmental Microbiology, vol. 56, p. 3878 - 3880.

- Davis, J.W., Klier, N.J., and Carpenter, 1994, Natural biological attenuation of benzene in ground water beneath a manufacturing facility: *Ground Water*, vol. 32, no. 2, p. 215-226.
- de Bont, J.A.M., Vorlage, M.J.W., Hartmans, S., and van den Tweel, W.J.J., 1986, Microbial degradation of 1,3-dichlorobenzene: *Applied and Environmental Microbiology*, v. 52, p. 677-680.
- De Bruin, W.P., Kotterman, M.J.J., Posthumus, M.A., Schraa, G., and Zehnder, A.J.B., 1992, Complete biological reductive transformation of tetrachloroethene to ethane: *Appl. Environ. Microbiol.*, vol. 58, no. 6, p. 1966 - 2000.
- DeStefano, T.D., Gossett, J.M., and Zinder, S.H., 1991, Reductive dehalogenation of high concentrations of tetrachloroethene to ethene by an anaerobic enrichment culture in the absence of methanogenesis: *Appl. Environ. Microbiol.*, vol. 57, no. 8, p. 2287-2292.
- Dewulf, J., Drijvers, D., and Van Langenhove, H., 1995, Measurement of Henry's law constant as function of temperature and salinity for the low temperature range. *Atmos. Environ.*, 29(3):323-331.
- Domenico, P.A., and Schwartz, F.W., 1990, *Physical and Chemical Hydrogeology*. John Wiley and Sons, New York, New York, 824p.
- Edwards, E., Wills, L.E., Grbic-Galic, D., and Reinhard, M., 1991, Anaerobic degradation of toluene and xylene--evidence for sulfate as the terminal electron acceptor, In: *In Situ Bioreclamation, Applications and Investigations for Hydrocarbon and Contaminated Site Remediation*. Eds. R.E. Hinchey and R.F. Olfenbittel. Butterworth-Heinemann. Boston, MA. p. 463-471.

- Edwards, E.A., and Grbic-Galic, D., 1992, Complete mineralization of benzene by aquifer microorganisms under strictly anaerobic conditions: Appl. Environ. Microbiol., vol. 58, p. 2663-2666.
- Edwards, E.A., Wells, L.E., Reinhard, M., and Grbic-Galic, D., 1992, Anaerobic degradation of toluene and xylene by aquifer microorganisms under sulfate-reducing conditions: Appl. Environ. Microbiol., vol. 58, p. 794-800.
- Evans, P.J., Mang, D.T., and Young, L.Y., 1991a, Degradation of toluene and m-xylene and transformation of o-xylene by denitrifying enrichment cultures: Appl. Environ. Microbiol., vol. 57, p.450-454.
- Evans, P.J., Mang, D.T., Kim, K.S., and Young, L.Y., 1991b, Anaerobic degradation of toluene by a denitrifying bacterium: Appl. Environ. Microbiol., vol. 57, p. 1139-1145.
- Fetter, C.W., 1993, Contaminant Hydrogeology: MacMillan, New York, New York, 458p.
- Folsom, B.R., Chapman, P.J., and Pritchard, P.H., 1990, Phenol and trichloroethylene degradation by *Pseudomonas cepacia* G4: Kinetics and interactions between substrates: Appl. Environ. Microbiol., vol. 56, no. 5, p. 1279-1285.
- Freedman, D.L., and Gossett, J.M., 1989, Biological reductive dehalogenation of tetrachloroethylene and trichloroethylene to ethylene under methanogenic conditions: Appl. Environ. Microbiol., vol. 55, no. 4, p. 1009-1014.
- Freeze, R.A., and Cherry, J.A., 1979, Groundwater. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
- Geraghty & Miller, Inc., 1994, AQTESOLV® Aquifer Test Solver, Version 2.0. Millersville, Maryland, October.

- Gibson, D.T., and Subramanian, V., 1984, Microbial degradation of aromatic hydrocarbons, In: Gibson, D.T., ed: Microbial Degradation of Organic Compounds, Marcel Dekker, Inc., p. 181-252.
- Godsey, E.M., 1994, Microbiological and geochemical degradation processes, In: Symposium on Intrinsic Bioremediation in Ground Water. Denver, CO. August 30 - September 1, 1994, p.35-40.
- Goldstein, R.M., Mallory, L.M., and Alexander, M., 1985, Reasons for Possible Failure of Inoculation to Enhance Biodegradation: Applied Environmental Microbiology, vol. 50, no. 4, p. 977-983.
- Grbic'-Galic', D., 1989, Microbial degradation of homocyclic and heterocyclic aromatic hydrocarbons under conditions: Dev. Ind. Microbiol., vol. 30, p. 237-253.
- Grbic'-Galic', D., 1990, Anaerobic microbial transformation of nonoxygenated aromatic and alicyclic compounds in soil, subsurface, and freshwater sediments, In: Bollag, J.M., and Stotzky, G., eds.: Soil Biochemistry: Marcel Dekker, Inc., New York, NY. p. 117-189.
- Haag, F., Reinhard, M., and McCarty, P.L., 1991, Degradation of toluene and p-xylene in an anaerobic microcosms: Evidence for sulfate as a terminal electron acceptor: Environ. Toxicol. Chem., vol. 10, p. 1379-1389.
- Haigler, B.E., Nishino, S.F., and Spain, J.C., 1988, Degradation of 1,2-dichlorobenzene by a *Pseudomonas* sp.: Applied and Environmental Microbiology, v. 54, p. 294-301.
- Harker, A.R., and Kim, Y., 1990, Trichloroethylene degradation by two independent aromatic-degrading pathways in *Alcaligenes eutrophus* JMP134: Appl. Environ. Microbiol., vol. 56, no. 4, p. 1179-1181.

- Hartmans, S., and de Bont, J.A.M., 1992, Aerobic vinyl chloride metabolism in *Mycobacterium aurum* Li: Appl. Environ. Microbiol., vol. 58, no. 4, p. 1220-1226.
- Hassett, J.J., Banwart, W.L., and Griffin, R.A., 1983, Correlation of compound properties with sorption characteristics of nonpolar compounds by soils and sediments; concepts and limitations, In, C.W. Francis and S.I. Auerbach, editors, Environment and Solid Wastes: Butterworths, Boston, p. 161-178.
- Henry, S.M., 1991, Transformation of Trichloroethylene by Methanotrophs from a Groundwater Aquifer. Ph.D. Thesis. Stanford University. Palo Alto, California.
- Hine, J., and Mookerjee, P.K., 1975, The Intrinsic Hydrophilic Character of Organic Compounds. Correlations in Terms of Structural Contributions: Journal of Organic Chemistry, 40(3):292-298.
- Hopper, D.J., 1978, Microbial Degradation of Aromatic Hydrocarbons, In: R.J. Watkinson (editor), Developments in Biodegradation of Hydrocarbons, I: Applied Science Publishers, Ltd., London.
- Howard, P.H., 1989, Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume I: Large Production and Priority Pollutants: Lewis Publishers, Inc, Chelsea, MI, 574 p.
- Howard, P.H., 1990, Handbook of Environmental Fate and Exposure Data For Organic Chemicals, Vol. II: Solvents: Lewis Publishers, Inc, Chelsea, Michigan, 546 p.
- Hutchins, S.R., and Wilson, J.T., 1991, Laboratory and field studies on BTEX biodegradation in a fuel-contaminated aquifer under denitrifying conditions, In: In Situ Bioreclamation, Applications and Investigations for Hydrocarbon and Contaminated Site Remediation. Eds. R.E. Hincbee and R.F. Olfenbuttel. Butterworth-Heinemann. Boston, MA. p. 157-172.

- Hutchins, S.R., Sewell, G.W., Sewell, D.A., Kovacs, D.A., and Smith, G.A., 1991a, Biodegradation of monoaromatic hydrocarbons by aquifer microorganisms using oxygen, nitrate, or nitrous oxide as the terminal electron acceptor: *Environ. Sci. Technol.*, vol. 25, no. 1, p. 68-76.
- Hutchins, S.R., Downs, W.C., Smith, G.B., Smith, J.T., Wilson, D.J., Hendrix, D.J., Fine, D.D., Kovacs, D.A., Douglass, R.H., and Blaha, F.A., 1991b, Nitrate for Biorestitution of an Aquifer Contaminated with Jet Fuel. U.S. Environmental Protection Agency. Robert S. Kerr Environmental Research Laboratory. Ada, Oklahoma. EPA/600/2-91/009. April, 1991.
- Isnard, S., and Lambert, S., 1988, Estimating Bioconcentration Factors from Octanol-Water Partition Coefficient and Aqueous Solubility: *Chemosphere*, vol. 17, no. 1, p. 21-34.
- Jamison, V.W., Raymond, R.L., and Hudson, J.O. Jr., 1975, Biodegradation of high-octane gasoline in ground water: *Developments in Industrial Microbiology*, vol. 16.
- Javandel, I., and Tsang, C., 1986, Capture-zone curves: a tool for aquifer cleanup: *Groundwater*, vol 24, no. 5, p. 616-625.
- Jeffers, P.M., Ward, L.M., Woytowitch, L.M., and Wolfe, N.L., 1989, Homogeneous hydrolysis rate constants for selected chlorinated methanes, ethanes, ethenes, and propanes: *Environmental Science and Technology*, v. 23, p. 965-969.
- Jury, W.A., Spencer, W.F., and Farmer, W.J., 1984, Behavior Assessment Model for Trace Organics in Soil: III, Application of Screening Model: *Journal of Environmental Quality*, 13(4):573-579.
- Karickhoff, S.W., Brown, D.S., and Scott, T.A., 1979, Sorption of hydrophobic pollutants on natural sediments: *Water Resources Research*, v. 13, p. 241-248.

- Kenaga, E.E., and Goring, C.A.I., 1980, ASTM Special Technical Publication 707: American Society for Testing Materials, Washington, D.C.
- Klier, N.J., West, R.J., and Donberg, P.A., 1996, Aerobic biodegradation of dichloroethylenes in surface and subsurface soils: Paper submitted to *Chemosphere*, May 1996.
- Klopffer, W., Haag, F., Kohl, E.G., and Frank, R., 1988, Testing of the abiotic degradation of chemicals in the atmosphere: the smog chamber approach. *Ecotoxicol. Environ. Saf.*, 15(3):298-319.
- Kuehne, D., and Buscheck, T., 1996, Survey of California marketing sites and analysis of monitoring well data: Chevron Research and Technology, unpublished report.
- Leahy, J.G., and Colewell, R.R., 1990, Microbial degradation of hydrocarbons in the environment: *Microbiological Reviews*, vol. 53, no. 3, p. 305-315.
- Lee, M.D., 1988, Bioremediation of Aquifers Contaminated with Organic Compounds: *CRC Critical Reviews in Environmental Control*. vol. 18. p. 29-89.
- Little, C.D., Palumbo, A.V., Herbes, S.E., Lidstrom, M.E., Tyndall, R.L., and Gilmer, P.J., 1988, Trichloroethylene biodegradation by a methane-oxidizing bacterium: *Appl. Environ. Microbiol.*, vol. 54, no. 4, p. 951-956.
- Lovley, D.R., and Phillips, E.J.P., 1988, Novel mode of microbial energy metabolism: organic carbon oxidation coupled to dissimilatory reduction of iron or manganese: *Applied and Environmental Microbiology*, v. 54, no. 6, p. 1472 - 1480.
- Lovley, D.R., Phillips, E.J.P., and Lonergan, D.J., 1991, Enzymatic versus nonenzymatic mechanisms for Fe(III) reduction in aquatic sediments: *Environmental Science and Technology*, v. 26, no. 6, p. 1062 - 1067.

- Lyman, W.J., Reidy, P.J., and Levy, B., 1992, Mobility and Degradation of Organic Contaminants in Subsurface Environments. C.K. Smoley, Inc., Chelsea, MI.
- Mackay, D., and Wolkoff, A.W., 1973, Rate of Evaporation of Low-Solubility Contaminants from Water Bodies to Atmosphere: Environmental Science and Technology, vol. 7, no. 7, p. 611-614.
- Mackay, D., and Shiu, W.Y., 1981, A Critical Review of Henry's Law Constants for Chemicals of Environmental Interest: Journal of Physical Chemistry Reference Data, vol. 10, no. 4, p. 1175-1199.
- Malone, D.R., Kao, C.M., and Borden, R.C., 1993, Dissolution and bioremediation of nonaqueous phase hydrocarbons - models development and laboratory evaluation: Water Resources Research, vol. 29, no. 7, p. 2003-2213.
- Mayer, K.P., Grbic-Galic, D., Semprini, L., and McCarty, P.L., 1988, Degradation of trichloroethylene by methanotrophic bacteria in a laboratory column of saturated aquifer material: Wat. Sci. Tech. (Great Britain), vol. 20, no. 11/12, p. 175-178.
- McCarty, P.L., Roberts, P.V., Reinhard, M., and Hopkins, G., 1992, Movement and transformations of halogenated aliphatic compounds in natural systems, In: Fate of Pesticides and Chemicals in the Environment. Ed., J.L. Schnoor. John Wiley & Sons, Inc. New York, New York. p. 191-209.
- McCarty, P.L., and Semprini, L., 1994, Ground-Water Treatment for Chlorinated Solvents, In: Handbook of Bioremediation. Lewis Publishers, Boca Raton, FL. 1994.
- Means, J.C., Wood, S.G., Hassett, J.J., and Banwart, W.L., 1980, Sorption of polynuclear aromatic hydrocarbons by sediments and soils: Environmental Science and Technology, v. 14, no., 12, p. 1524-1528.

- Miller, R.E., and Guengerich, F.P., 1982, Oxidation of trichloroethylene by liver microsomal cytochrome P-450: Evidence for chlorine migration in a transition state not involving trichloroethylene oxide: *Biochemistry*, vol. 21, p. 1090-1097.
- Miller, M.M., Wasik, S.P., Huang, G.L., Shiu, W.Y., and Mackay, D., 1985, Relationships Between Octanol-Water Partition Coefficient and Aqueous Solubility: *Environmental Science and Technology*, v. 19, no. 6, p. 522-529.
- Mississippi Department of Environmental Quality (MDEQ). 1991. Office of Pollution Control, Groundwater Division, Groundwater Quality Standards, Section 3, Numerical Groundwater Standards.
- Montgomery, J.J. 1996. Groundwater Chemicals Desk Reference. Lewis Publishers, Boca Raton.
- Moutoux, D.E., L.A. Benson, J. Lenhart, T.H. Wiedemeier, J.T. Wilson, and J.E. Hansen. 1996. Estimating the changing rate of anaerobic reductive dehalogenation of chlorinated aliphatic hydrocarbons in the presence of petroleum hydrocarbons. Proceedings of the 1996 Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Remediation. Houston, TX, November 13 - 15, 1996.
- Murray, W.D. and Richardson, M., 1993, Progress toward the biological treatment of C₁ and C₂ halogenated hydrocarbons: *Critical Reviews in Environmental Science and Technology*, v. 23, no. 3, pp. 195-217.
- Nelson, M.J.K., Montgomery, S.O., O'Neill, E.J., and Pritchard, P.H., 1986, Aerobic metabolism of trichloroethylene by a bacterial isolate: *Appl. Environ. Microbiol.*, vol. 52, no. 2, p. 949-954.
- Nishino, S.F., Spain, J.C., and Pettigrew, C.A., 1994, Biodegradation of chlorobenzene by indigenous bacteria: *Environ. Toxicol. Chem.*, v. 13, p. 871-877.

- Pankow, J.F., and Rosen, M.E., 1988, Determination of Volatile Compounds in Water by Purging Directly to a Capillary Column with Whole Column Cryotrapping: *Environmental Science and Technology*, vol. 22, no. 4, p. 398-405.
- Parsons Engineering Science (Parsons ES), 1996, Work Plan for a Treatability Study for RNA at Sites ST-24 and LF-06, Columbus AFB, Mississippi, September.
- Pearson, C.R. and McConnell, G., 1975, Chlorinated C1 and C2 hydrocarbons in the marine environment. *Proc. R. Soc. London*, B189(1096):305-332.
- Perry, J.J., 1984, Microbial Metabolism of Cyclic Alkanes, In: Atlas, R.M. ed.: *Petroleum Microbiology*. Macmillan Publishing Co., New York, New York.
- Reineke, W., and Knackmuss, H.-J., 1984, Microbial metabolism of haloaromatics: Isolation and properties of a chlorobenzene-degrading bacterium: *European Journal of Applied Microbiology and Biotechnology*, v. 47, p. 395-402.
- Reinhard, M., Goodman, N.L., and Barker, J.F., 1984, Occurrence and distribution of organic chemicals in two landfill leachate plumes: *Environ. Sci. Technol.*, vol. 18, no. 12, p. 953-961.
- Ribbons, D.W., and Eaton, R.W., 1992, Chemical Transformations of Aromatic Hydrocarbons that Support the Growth of Microorganisms, In: Mitchell, R., ed.: *Environmental Microbiology*. Wiley-Liss, New York, NY.
- Rice, D.W., Grose, R.D., Michaelsen, J.C., Dooher, B.P., MacQueen, D.H., Cullen, S.J., Kastenber, W.E., Everett, L.G., and Marino, M.A., 1995, California Leaking Underground Fuel Tank (LUFT) Historical Case Analyses: Environmental Protection Department, Environmental Restoration Division, Lawrence Berkely laboratories, UCRL-122207, prepared for the California State Water Resources Control Board.

- Sander, P., Wittaich, R.-M., Fortnagel, P., Wilkes, H., and Francke, W., 1991, Degradation of 1,2,4-trichloro- and 1,2,4,5-tetrachlorobenzene by *Pseudomonas* strains: Applied and Environmental Microbiology, v. 57, p. 1430-1440.
- Schraa, G., Boone, M.L., Jetten, M.S.M., van Neerven, A.R.W., Colberg, P.J., and Zehnder, A.J.B., 1986, Degradation of 1,2-dichlorobenzene by *Alcaligenes* sp. strain A175: Applied and Environmental Microbiology, v. 52, p. 1374-1381.
- Schwille, F., 1988, Dense Chlorinated Solvents. Lewis Publishers, Inc., Chelsea, MI, p. 146.
- Spain, J.C., 1996, Future vision: Compounds with potential for natural attenuation, In Proceedings of the Symposium on Natural Attenuation of Chlorinated Organics in Ground Water: EPA /540/R-96/509, Dallas TX, September 11-13, 1996.
- Spain, J., 1997, Personal communication between Jim Spain of the US Air Force Armstrong Laboratory and Matt Swanson of Parsons ES regarding potential anaerobic utilization of chlorobenzenes as substrates. March 7, 1997.
- Spain, J.C., and Nishino, S.F., 1987, Degradation of 1,4-dichlorobenzene by a *Pseudomonas* sp.: Applied and Environmental Microbiology, v. 53, p. 1010-1019.
- Spencer, Robert H., 1996a, 1995 Initial Monitoring Report for Long Term Monitoring Program, Columbus Air Force Base, Columbus, Mississippi, prepared for US Army Corps of Engineers Mobile District, March.
- Spencer, Robert H., 1996b, Well Assessment Report for Long Term Monitoring Program, Columbus Air Force Base, Columbus, Mississippi, prepared for US Army Corps of Engineers Mobile District, May.
- Stauffer, T.B., Antworth, T.B., Boggs, J.M., and MacIntyre, W.G., 1994, A Natural Gradient Tracer Experiment in a Heterogeneous Aquifer with Measured In Situ

Biodegradation Rates: A Case for Natural Attenuation, in Proceedings of the Symposium on Intrinsic Bioremediation of Ground Water, August 30 - September 1, 1994: US Environmental Protection Agency, p. 73 - 84.

Stewart, Troy, 1997, Personal communication. Environmental Engineer, 14 CES/CEV, Columbus AFB. RE: Groundwater use near Site ST-24. April.

Stumm, W. and Morgan, J.J., 1981, Aquatic Chemistry. John Wiley & Sons, New York, NY.

Suflita, J.M., and Townsend, G.T., 1995, The microbial ecology and physiology of aryl dehalogenation reactions and implications for bioremediation, In Young, L.Y., and Cerniglia, C.E., eds., Microbial Transformation and Degradation of Toxic Organic Chemicals: Wiley-Liss, New York, 654 p.

Thierrin, J., Davis, G.B., Barber, C., Patterson, B.M., Pribac, F., Power, T.R., and Lambert, M., 1992, Natural degradation rates of BTEX compounds and naphthalene in a sulfate-reducing ground water environment, In: In-Situ Bioremediation Symposium "92". Niagara-on-the-Lake, Ontario, Canada. September 20-24, 1992: In Press.

US Environmental Protection Agency (USEPA), 1988, Guidance for Conducting Remedial Investigations and Feasibility Studies (RI/FS) Under CERCLA. OSWER Directive 9355.3-01.

USEPA, 1991, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)*. Interim. Publication 9285.7-01B.

USEPA, 1993, Revisions to the OMB Circular A-94 on Guidelines and Discount Rates for Benefit Cost Analysis, OSWER Directive 9355.3-20, June.

- US Geological Survey (USGS), 1987, 7.5 Minute Quadrangle Map of the Columbus North and Hamilton Quadrangles, Mississippi.
- Valsaraj, K.T., 1988, On the Physio-Chemical Aspects of Partitioning of Non-Polar Hydrophobic Organics at the Air-Water Interface: *Chemosphere*, vol. 17, no. 5, p. 875-887.
- van der Meer, J.R., Roelofsen, W., Schraa, G., and Zehnder, A.J.B., 1987, Degradation of low concentrations of dichlorobenzenes and 1,2,4-trichlorobenzene by *Pseudomonas* sp. strain P51 in nonsterile soil columns: *FEMS Microbiology Letters*, v. 45, p. 333-341.
- van Genuchten, M. T., and Alves, W. J., 1982, Analytical Solutions of the One-Dimensional Convective-Dispersive Solute Transport Equation: US Department of Agriculture, Technical Bulletin Number 1661, 151p.
- Verschueren, K., 1983, Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, New York.
- Vogel, T.M., 1994, Natural Bioremediation of Chlorinated Solvents, In: Handbook of Bioremediation. Lewis Publishers, Boca Raton, FL. 1994.
- Vogel, T.M., and McCarty, P.L., 1985, Biotransformation of tetrachloroethylene to trichloroethylene, dichloroethylene, vinyl chloride, and carbon dioxide under methanogenic conditions: *Applied Environmental Microbiology*, v. 49, no. 5, pp. 1080-1083.
- Vogel, T.M., Criddle, C.S., and McCarty, P.L., 1987, Transformations of halogenated aliphatic compounds: *Environmental Science and Technology*, vol. 21, no. 8, p. 722 - 736.

- Vroblecky, D.A., and Chapelle, F.H., 1994, Temporal and spatial changes of terminal electron-accepting processes in a petroleum hydrocarbon-contaminated aquifer and the significance for contaminant biodegradation: *Water Resources Research*, v. 30, no. 5, p. 1561-1570.
- Wiedemeier, T.H., Wilson, J.T., Kampbell, D.H., Miller, R.N., and Hansen, J.E., 1995, Technical Protocol for Implementing Intrinsic Remediation with Long-term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Ground Water. Prepared by the Air Force Center for Environmental Excellence.
- Wiedemeier, T.H., Swanson, M.A., Wilson, J.T., Kampbell, D.H., Miller, R.N., and Hansen, J.E., 1996b, Approximation of biodegradation rate constants for monoaromatic hydrocarbons in ground water: *Ground Water Monitoring and Remediation*, v. 16, no. 3, p. 186-194.
- Wiedemeier, T.H., Swanson, M.A., Moutoux, D.E., Gordon, E.K., Wilson, J.T., Wilson, B.H., Kampbell, D.H., Hansen, J.E., Haas, P., and Chapelle, F.H., 1996a, Technical protocol for evaluating natural attenuation of chlorinated solvents in groundwater (Draft - revision 0): prepared for the Air Force Center for Environmental Excellence, San Antonio, TX.
- Wiedemeier, T.H., Swanson, M.A., Wilson, J.T., Kampbell, D.H., Miller, R.N., and Hansen, J.E., 1996b, Approximation of biodegradation rate constants for monoaromatic hydrocarbons in ground water: *Ground Water Monitoring and Remediation*, v. 16, no. 3, p. 186-194.
- Wilson, J.T., and Wilson, B.H., 1985, Biotransformation of trichloroethylene in soil: *Appl. Environ. Microbiol.*, vol. 49, no. 1, p. 242-243.
- Wilson, B.H., Smith, G.B., and Rees, J.F., 1986, Biotransformations of Selected Alkylbenzenes and Halogenated Aliphatic Hydrocarbons in Methanogenic Aquifer

Material: A Microcosm Study: Environmental Science and Technology, 20(10):997-1002.

Wilson, B.H., Bledsoe, B., and Kampbell, D., 1987, Biological processes occurring at an aviation gasoline spill site, In: R.C. Averett and D.M. McKnight editors, Chemical Quality of Water and the Hydrologic Cycle. Lewis Publishers, Chelsea, Michigan, p.125-137.

Wilson, B.H., Wilson, J.T., Kampbell, D.H., Bledsoe, B.E., and Armstrong, J.M., 1990, Biotransformation of Monoaromatic and Chlorinated Hydrocarbons at an Aviation Gasoline Spill Site: Geomicrobiology Journal, 8:225-240.

Wilson, B.H., Wilson, J.T., Kampbell, D.H., and Bledsoe, B.E., 1994, Traverse City: Geochemistry and Intrinsic Bioremediation of BTEX Compounds, In: Proceedings of the Symposium on Intrinsic Bioremediation of Ground Water. August 30 - September 1, 1994. US Environmental Protection Agency, p. 94 - 102.

Wilson, J.T., 1996, Personal communication between John Wilson of the USEPA NRMRL and Todd Wiedemeier of Parsons ES regarding USEPA definition of the term "natural attenuation", citing USEPA guidance undergoing internal review.

Young, L.Y., 1984, Anaerobic degradation of aromatic compounds, In: Gibson, D.R., ed.: Microbial Degradation of Aromatic Compounds. Marcel-Dekker, New York.

APPENDIX A

APPENDIX A-1
GEOLOGIC BORING LOGS

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: LF06-MPC CONTRACTOR: PARSONS ES DATE SPUD: 11/16/96
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL.: 11/16/96
 JOB NO.: 729691 DRLG METHOD: Geoprobe ELEVATION: 65
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/8" TEMP: 50-55-60° F
 GEOLOGIST: B. Henry DRLG FLUID: NA WEATHER: Pt. Cloudy - Breezy
 COMMENTS: C. Snider

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PD (ppm)	Ambient pH	TOTAL BTEX (ppm)	IPH (ppm)
0-4 3' Rec. (75%)	1		CL/ML	CLAY & SILT - reddish brown to yellow brown, soft-firm, v silty-sandy, moist, trace gravel, no odor	0910		D		78	0.0		
4-8 4' Rec. (100%)	5		CL	4-8' SILTY CLAY - yellowbrown turning brick red, soft-si stiff, si moist, massive, no odor			D		37	0.0		
8-12 4' Rec. (100%)	10		CL/ML	8-12' SILTY CLAY - brick red, soft-si stiff, massive, trace gravel chunks, si moist, grading to orangish brown SILT at 11.5'	0920		D		94	0.0		
12-16 4' Rec. (100%)			ML/SM	12-14' CLAYEY SILT - sandy-AA, grading to SAND (14-16') - orangish brown, uf-f gr, silty, mod sates, loose, dense, w/ thin interbeds of clayey matrix			D		85	0.0		
16-18 2' Rec. (100%)	15		SC	16-18 SAND - orangish brown, uf-f gr, with thin 6" gravel bed at 17.5', some clay matrix, loose, v. moist to damp			D		66	0.0		
18-20 2' Rec. (100%)	20			18-20 SAND - brown to gray brown, AA, with thin interbeds of rounded gravel to 1", wet	WATER ~ 18'		D		95	0.0		
23-25 1.5' Rec. (75%)	25		SC	23-25' SAND & GRAVEL - AA - saturated			D		62	0.0		
34-36 1' Rec.	35		SC	Drive spun to 34' → Drive like Sarcocoe								
				SAMPLE 34-36' - SAND & GRAVEL - brown, f. cvs gr, w/ gravel to 1", sub angular-ravel, poorly sorted, loose, satval								

Screen 20-23' (Pre Pack)
 31-31.5' (Inplant)

NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE

D - DRIVE
 C - CORE
 G - GRAB

▼ Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: LF06-MPD CONTRACTOR: PARSONS ES DATE SPUD: 11/16/96
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL: 11/16/96
 JOB NO.: 729691 DRLG METHOD: Geoprobe ELEVATION: 65
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/8" TEMP: 60-65°F
 GEOLOGIST: B. Lenny DRLG FLUID: NA WEATHER: Clear - Pkly Cloudy
 COMMENTS: C. Snyder

Elev (ft)	Depth (ft)	Pro file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PI (ppm)	Ambient (ppm)	TOTAL BTX (ppm)	TPH (ppm)
0-4' Rec 75%	1		Back Fill	0-3.5' BACKFILL - CLAYEY SAND & GRAVEL - brown, v. poorly sorted, v. - cvs gr w/ gravel, clay mty, firm - hard, st. moist			D		15	0.0		
4-9' Rec 75%	5		LAND FILL	3.5-4.0' LANDFILL TRASH - plastic & glass w/ mixed in clay			D		170	0.0		
8-11' Rec 100%	10		Fill	4-8' SILTY CLAY Backfill w/ LANDFILL TRASH - fiber, wood, styrofoam			XZ1		95	0.0		
11-14' Rec 3' (100%)	15		CL	8-12' SILTY CLAY - gray brown, firm - v. stiff, silty, moist, massive - water at 9-10'			D		90	0.0		
14-16.5' Rec 2' (60%)	20		CL	11-14' SILTY CLAY - gray, mottled red, firm - stiff, v. silty, grady to 3-11' SILTY SAND at base, v. moist - is wet			D		100	0.0		
16.5-18' Rec 1' (50%)	25		CL	14-16.0' SILTY-SANDY CLAY - AA, turning reddish brown, 16.0-16.5' SANDY GRAVEL - v. - cvs gr. gravel to 3/4", poorly sorted wet, loose			D		83	0.0		
	30		SC/ SW	16.5-18.5' SANDY GRAVEL - AA								
	35			Drive to 30'								
	30-32' Rec 1' (50%)		SC/ SW	30-32' SAND & GRAVEL - brown, v. - cvs gr. gravel to 1/2", poorly sorted, loose, wet			D		126	0.0		

SET 3' Pre Pak Screen (1/2" dia) at 15-18' / Set 6" insert 31-31.5'

NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE

D - DRIVE
 C - CORE
 G - GRAB



Water level drilled

1615 off location.

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: LF06-MPF CONTRACTOR: PARSONS ES DATE SPUD: 11/15/96
 CLIENT: AFCEE RIG TYPE: Casapche DATE CMPL.: 11/15/96
 JOB NO.: 729691 DRLG METHOD: Casapche ELEVATION: 65
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/8" TEMP: 60-65°F
 GEOLOGIST: B. Henry DRLG FLUID: NA WEATHER: clear
 COMMENTS: C. Snyder

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PD (ppm)	Amb (ppm)	TOTAL BTEX (ppm)	TPH (ppm)
0-1 2' Rec. (50%)	1	CL	CL	0-3' CLAY - reddish brown, soft, moist, backfill material	1	3-4"	D		75	10.0		
4-8 1' Rec. (25%)	5	LAND FILL	LAND FILL	3-4' LANDFILL TRASH - Plastic sheeting w/ black decomposed organic matter								
8-10.5 2' Rec. (100%)	10	FILL	FILL	4-8' LANDFILL TRASH - black, gray, decomposed organic matter w/ some clay material, wet					210	10.0		
10-12 2' Rec. (100%)	15	CL	CL	8-9' CLAY - reddish brown, mottled gray, soft - stiff, v. silty, moist					320	10.0		
		SC	SC	9-10' CLAYEY SAND & GRAVEL, reddish brown/usc - firm, v. poorly sorted, moist - wet, slight odor 10-11' AN					75	10.0		
		SC	SC	11-12' SAND - orangish brown, F-m gr, well sorted, silty, up to loose, close, wet					79	10.0		
		SP	SP	12-14' SAND - brown, gray brown, F gr, well sorted, some clay, mtr, loose, close, v. moist, but not wet, hydrocarbon odor, gravel at base 2"								
18-20 1.5' Rec. (75%)	25	SC	SC	Switch to small sampler 18-20' SAND - reddish brown, loose, F-m gr, mod sorted, w/ layers of poorly sorted gravel, wet, no odor								
26-28 2.5' Rec. (16%)	30	SC	SC	26-28' SAND & GRAVEL - wet					NR			
33-34.5 0.5' Rec. (33%)	35	SC	SC	33-34.5' SAND & GRAVEL - orangish brown, ut - cvs gr, gravel to 1", poorly sorted, silty-clayey, loose, saturated					NR			

NOTE:

WATER IN SAMPLER HAS SHEEN ON IT

Couldn't go beyond 35' - did not encounter continuing layer. → Set 3' of Screen from

NOTES 11-14' / Set 6" Insert at 30.5-31' SAMPLE TYPE

bgs - Below Ground Surface D - DRIVE
 GS - Ground Surface C - CORE
 TOC - Top of Casing G - GRAB

NS - Not Sampled
 SAA - Same As Above

Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: LF06-MPG CONTRACTOR: Parsons ES DATE SPUD: 11/13/96
 CLIENT: AFCEE RIG TYPE: Gesp. probe DATE CMPL.: 11/13/96
 JOB NO.: 729691 DRLG METHOD: " ELEVATION: GS
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/4" TEMP: 50°F
 GEOLOGIST: B. Henry DRLG FLUID: NA WEATHER: Cloudy
 COMMENTS: C. Snyder

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PIV(ppm)	ILV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
0-4' 1.0' Rec. (25%)	1	0-4'	SW	Gravelly SAND - f-crs gravel, gravel to 1.5", poorly sorted, moist, silt-clay matrix, orange-brown, mod. dense, no stain or odor.	1	0-4'	D		21.2 0.0			
4-8' 2 1/2' Rec. 60%	5	4-8'	SP/SM	SILTY SAND - gray, interbedded w/ red, silty-clayey matrix, mod. well sorted, dense, moist, no stain or odor, → Samplers Packed off.	2	4-8'	D		34.7 0.0			
10-12' (75%)	10	10-12'	CL	Drive 2' Sample to 9.5' - sample 10-12' SILTY CLAY - orangeish brown, mottled gray, silty, very stiff, mod. plastic, dense, moist, no stain or odor			D	10-12	52.0/0.0			
14-16' (80%)	15	14-16'	CL SP	14-15' SILTY CLAY - reddish brn, very stiff, moist, <u>NSD</u>			Water e 11-12	14-16	44.6/0.0			
16-18' (75%)	20	16-18'	SP/SM	15-16' SILTY SAND - light gray, very fine grained, well sorted, loose- friable, very moist, dense, <u>NSD</u>			D	16-18	52.0/0.0			
	25			16-18' SAND - 6" light gray, AA, becoming reddish brown, very fine to fine grained, mod. well sorted, friable-loose, w/ bottom 3" poorly sorted w/ gravel to 1/2". Saturated.								
	30			T.D @ 18', Drive 2 1/2" Rod to TD, set well								
	35			Screen @ 15-18' (3/4" Pre-Pak PVC) w/ 20' Drive → cut back to 15'								

/10:15 - Done /

NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE

D - DRIVE
 C - CORE
 G - GRAB
 ▼ Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

Sheet 1 of 1

BORING NO.:	LF06 - MPH	CONTRACTOR:	PARSONS ES	DATE SPUD:	11/13/96
CLIENT:	AFCEE	RIG TYPE:	Geoprobe	DATE CMPL.:	11/13/96
JOB NO.:	729691	DRLG METHOD:	Geoprobe	ELEVATION:	GS
LOCATION:	COLUMBUS AFB	BORING DIA.:	2 1/4"	TEMP:	55-60°F
GEOLOGIST:	B. Henry	DRLG FLUID:	NA	WEATHER:	Cloudy, Cool
COMMENTS:	G. Snyder				

[illegible]

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D - DRIVE
C - CORE
G - GRAB

 Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
Intrinsic Remediation TS
Columbus AFB, Mississippi

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: LF06-MPI CONTRACTOR: PARSONS ES DATE SPUD: 11/15/96
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL.: 11/15/96
 JOB NO.: 729691 DRLG METHOD: Geoprobe ELEVATION: GS
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/8" TEMP: 50°F
 GEOLOGIST: B. Henril DRLG FLUID: NA WEATHER: Clear & Sunny
 COMMENTS: C. Snyder

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PD (ppm)	Ambiq (ppm)	TOTAL BTEX (ppm)	TPH (ppm)
0-4'	1		CL	SILTY CLAY - gray to reddish brown, soft-firm, v. silty, moist	0745		D		80	0.0		
3' Rec (75%)												
4-8'	5		CL	4-8' SILTY CLAY - gray, mottled orangish brown, soft-friable, stiff in part, v. silty, moist non-plastic	805		D		102	0.0		
3' Rec (75%)												
8-11.5'			CL	8-11.5 SILTY CLAY - AA								
3' Rec (60%)												
11.5-14'	10		CL	11.5-14' SILTY CLAY - gray, mottled orangish brown, soft-firm, v. stiff in part, moist, v. silty, no odor	819		D		85	0.0		
2' Rec (80%)												
14-17'				14-17' SILTY CLAY - AA, increasing v. sandy at 16-17'								
3' Rec (100%)	15				0845		D		89	0.0		
17-19.5'		CL/SM		17-19.5' Interbedded SILTY CLAY - AA, w/ SILT - orangish brown, silt-uf gr w/ some clay matrix, soft, v. moist to wet								
2' Rec	20								57	0.0		
19.5-22.5'		SP/SC		19.5-22.5' SAND - orangish brown, uf-f grained, silty, well sorted, some clay mtr, loose, dense, wet, nodular, grading to gravelly SAND at 21.5-22.5 - w/ gravel to 1/2"	0928				40	0.0		
3' Rec (100%)	25											
		SP/SC		Drive ahead w/ small sampler to 25' sample 25-27					26	0.0		
	30		CL	25-27' SAND - orangish brown, uf-f gr, silty, loose, dense, mod sorted, wet, w/ some clay - reddish interbeds								
				28' -> TOP CONFINING ZONE								
				28-29.5' CLAY - weathered, gray w/ reddish oxidation,								
	35											

1130 Set Screen
 3' Pre Pak e
 23-26'
 NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE
 D - DRIVE
 C - CORE
 G - GRAB

Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

PARSONS
ENGINEERING SCIENCE, INC.

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: MP-J(LF6) CONTRACTOR: Parsons ES DATE SPUD: 11/8/96
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL.: 11/8/96
 JOB NO.: 729691 DRLG METHOD: Geoprobe ELEVATION: 200
 LOCATION: COLUMBUS AFB BORING DIA.: 1 3/4" TEMP: 60°
 GEOLOGIST: RDN DRLG FLUID: --- WEATHER: broazy, sunny
 COMMENTS: ---

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PI (ppm)	TLV (ppm)	TOTAL BTEX (ppm)	TPH (ppm)
100	1			0-2 Brown sandy SILT		2			12			
88	2.5			2-4.5 Brown + Orange silty SAND		4			33			
78	5			6.5-11.5 Brown, orange, and gray, clayey SAND		6			40			
75				Very		8			25			
60				Red		10			0			
60	10		SM	10.5-12 Brown orange silty SAND		12			10			
95			SW	12-13.5 Orange-brown gravel w/silty sand		14			8.0			
80	15			13.5-14.0 Yellow-green slightly silty SAND		16			2.3			
70			SW	14.0-18 Yellow + orange gravel w/silty SAND		18			67			
	20		SM									
	25			Sampled TOC (16-18')								
	30											
	35											

NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE

D - DRIVE
 C - CORE
 G - GRAB

▼ Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: LF06-MPK CONTRACTOR: PARSONS ES DATE SPUD: 11/14/96
 CLIENT: AFCEE RIG TYPE: Cheapdrill DATE CMPL.: 11/14/96
 JOB NO.: 729691 DRLG METHOD: Cheapdrill ELEVATION: GS
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/4" TEMP: Clean-Drill Clay
 GEOLOGIST: B. Henry DRLG FLUID: NA WEATHER: 60°F
 COMMENTS: G. Snyder

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PIB (ppm)	Ambient (ppm)	TOTAL BITEX (ppm)	TPH (ppm)
0-3.5 2' Rec. (55%)	1		CL	0-3.5 SILTY CLAY - Red-brown, Firm, very silty - sandy, moist, no odor	0452		D		87.0	0.0		
3.5-6.5			CL	3.5-6.0' - Red Silty CLAY - A.P.								
6.5-9.0 2 1/2 Rec. (89%)	5		SW	6.0-6.5' - SAND GRAVEL - reddish brown, vt - m gr, w/ gravel to 1", silty - clayey matrix, loose, med dense, moist, poorly sorted	1000		D		66	0.0		
9.0-11.0 2' Rec. (55%)	10		SC/SW	6.5-9.0' GRAVELLY SAND - reddish brown, very f - fine grained, w/ gravel to 1" (LS), silt & clay matrix, loose, dense, moist, very poorly sorted					120	0.0	(SAT 10 SW)	
11.0-13.0 2' Rec. (100%)									45	0.0		
13.0-15.0 1' Rec. (50%)	15		SC	9.0-11.0 SAND - orange to reddish brown, very f - f grained, some gravel to 1", silt & clay mtr, thin 6" layers of clayey sand, loose, dense, moist	1037				142	0.0		
15.0-18.0 1' Rec. (50%)	20		SC	11.0-13.0 SAND - orange to reddish brown, very f - f grained, some gravel to 1", silt & clay mtr, thin 6" layers of clayey sand, loose, dense, moist					95	0.0		
	25		SC	13.0-15.0 SAND - orange to reddish brown, very f - f grained, some gravel to 1", silt & clay mtr, thin 6" layers of clayey sand, loose, dense, moist					113	0.0		
	30		SC/SW	15.0-18.0 SANDY GRAVEL - orange to reddish brown, vt - m gr, w/ gravel to 1", silty - clayey matrix, loose, med dense, wet at base. WATER @ 13 1/2'								
	35											

1120 Set 3' of Pre-Pack Screen - (1 1/2" PVC - 10 slot) at 15 - 18'

NOTES 1145 DONE MPK SAMPLE TYPE

bgs - Below Ground Surface D - DRIVE
 GS - Ground Surface C - CORE
 TOC - Top of Casing G - GRAB
 NS - Not Sampled
 SAA - Same As Above

▼ Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: LF06-MPL CONTRACTOR: PARSONSES DATE SPUD: 11/14/96 - 0700
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL: 11/14/96 - 0930
 JOB NO.: 729691 DRLG METHOD: Geoprobe ELEVATION: 65
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/4" TEMP: Clear - Pt. Cloudy
 GEOLOGIST: B. Henry DRLG FLUID: N/A WEATHER: 50-60°F
 COMMENTS: G. Snicker

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PI (ppm)	Ambient (ppm)	TOTAL BTEX (ppm)	TPH (ppm)
0-4'	1		SW	0-4' SAND + GRAVEL - Red-brown, v. fine gr w/ gravel to 1/4", silty, clayey at top, med dense, loose, sl. moist			D	0720	46.5	0.0		
4-7	5		SW	4-7' SAND + GRAVEL - inc. gravel in 1 1/2" dia			b	0723	56.5	0.0		
7-9			SW	7-9' SAND + GRAVEL - Reddish brown, f. fine grained w/ gravel to 1", loose, poorly sorted, angular, sl. moist, no odor			D	0750	59	0.0		
9-10	10						D	0825	69	0.0		
10-11			SW	9-11 SAND + GRAVEL - AA - becoming very moist, no odor			D	0835	61	0.0		
11-13	15		SW	11-13' SAND + GRAVEL - Orangeish to reddish brown, f. fine gr w/ gravel to 1", very poorly sorted, silty layers w/ clay matrix, angular, loose, bottom 6" saturated, water at 12.5'			D	0940	NR	NR		
15-17	25			Drive small Rod to 15', Sample 15-17'								
				15-17 SAND + GRAVEL - AA (SATURATED)								
				TD at 17' bgs								
				-Tried to set 3' Pre Pack Sam, well flawed a sand packed screen in pipe, Reset 5' at 0.5" PVC lost at 12-17' bgs.								

NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 .NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE

D - DRIVE
 C - CORE
 G - GRAB

▼ Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: LFOG-MPN CONTRACTOR: PARSONS ES DATE SPUD: 11/16/96
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL: 11/16/96
 JOB NO.: 729691 DRLG METHOD: Geoprobe ELEVATION: G.S.
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/8" TEMP: 40-50°F
 GEOLOGIST: B. Henry DRLG FLUID: NA WEATHER: Clear & Calm
 COMMENTS: C. Snyder

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PIV(ppm)	Amst #(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
0-4 3' Rec. 75%	1		CL	0-4 SILTY CLAY - brown, reddish brown, v. silty, soft-firm, stiff in part moist	0635		C		89	0.0		
4-7.5 3.5' Rec. 100%	5		CL	4-7.5 SILTY TO SANDY CLAY - brick red, soft, sl moist, friable, w/ trace L.S. fragments to 1/4"			C		69	0.0		
7.5-11.5 3.5' Rec. (88%)			CL ML SM	7.5-10.5 - SILTY TO SANDY CLAY - brick red-AA - inc. sandy 10.5-11.5 SILTY SAND - orangish brown, uf-f gr, silty, mod sorted, soft-look, sl moist, no odor			D		83	0.0		
11.5-15.5 3' Rec. 75%			SM	11.5-15.5 SILTY SAND - orangish to reddish brown, uf grained, silty, sme clay mtr, v. loose, mod sorted, clean-noodle			D		77	0.0		
15.5-19 3.5' Rec. (100%)	15			15.5-18.5' SILTY SAND-AA			D		80	0.0		
19-21 2' Rec. (100%)	20		SC SW	18.5-19.0' Gravely SAND - orangish brown, uf-f gr, w/ gravel to 1/2", poorly sorted, loose, clump, dense, no odor			D		66	0.0		
23-25 1' Rec. (50%)	25		SW	19.0-21.0 - SANDY GRAVEL - reddish brown, f-cvs gr w/ gravel to 1", v. poorly sorted, angular, loose, dense, wet at base Dre Small sample - Sample 23-25'			D		79	0.0		
			TS	23-23' SANDY GRAVEL - orangish brown to gray, f-cvs gr w/ gravel to 1/2", poorly sorted, loose, subangular-rounded, saturated.								
	30		0820	Draw Rod to 27' - SET 3' of Pre Pak 10-slot 1/2" dia PUK Screen at 24-27'								
	35		0830	OFF LOCATION								

NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE

D - DRIVE
 C - CORE
 G - GRAB

▼ Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: LF06-MPO CONTRACTOR: Parsons ES DATE SPUD: 11/13/96
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL: 11/13/96
 JOB NO.: 729691 DRLG METHOD: Geoprobe ELEVATION: 65
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/4" TEMP: 50°F, calm
 GEOLOGIST: B. Henry DRLG FLUID: NA WEATHER: Cloudy
 COMMENTS: G. Snyder

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample	Sample	Penet Res	Amber	TOTAL	TPH
					No.	Depth (ft)		Type	PID(ppm)	BTEX(ppm)
90%R (3.6')	1		CL	0-4 SILTY CLAY - gray, mottled orange, silty, stiff, moist, no stain or odor	0-2	D		25.5/0.0		
					2-4 (1345)	D		17.8/0.0		
4-7'	5		CL	4-6' SILTY CLAY-AA, increasing silty, orangeish brown, stiff, becoming friable, moist				41.0/0.0		
100%R (3')								59.7/0.0		
7-10 (65%R) (2')			CL/SM	6-7' silty-sandy CLAY-H. gray; friable, firm, moist, inc silty sand w/ silty layers no odor	4-7 (1405)	D		37.9/0.0		
	10		SM/SP	7-10 - SILTY-CLAYEY SAND, light gray, loose, silt-uf grained, well sorted, moist, slight odor in sandier sections, dense	7-10 1420	D		29.0/0.0		
	15				11-13 1433	D		32.0/0.0		
	20		SP/SM	10-11 - Silty-Sand/CLAY-AA				SOIL BACKGROUND ~ 20-40 ppm		
			SP	11-13' SAND - orange, mottled gray, loose, uf-f grained, well sorted, wet, dense, no odor, some interbedded clayey layers						
	25									
	30		1500	Set Screen 9-14' 0.5" PVC → 5' at 10 slot + 2x 5' Risers						
	35									

NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE

D - DRIVE
 C - CORE
 G - GRAB

▼ Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: MPP(LF06) CONTRACTOR: Parsons ES DATE SPUD: 11/12/96 1115
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL: 11/12/96 1200
 JOB NO.: 729691 DRLG METHOD: Geoprobe ELEVATION: 60'
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/8 TEMP: 60°
 GEOLOGIST: RDN DRLG FLUID: — WEATHER: Cloudy
 COMMENTS:

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	TLV(ppm)	TOTAL BTX(ppm)	TPH (ppm)
88 1/2	1			0+1 Brown wet sandy Silt	2				0.0			
				1-1.2 Thin layer of crumbled asphalt.	4				0.0			
90 1/2	5			1.2-3 Red sandy clayey SILT w/ gravel	6				0.0			
				3-4 Tan-brown sandy SILT very	8				0.0			
100 1/2	10			4-8 Tan and gray clayey SILT marbled w/ gray sandy clay	10				0.0			
90 1/2	15			(70% clayey silt)	12				0.0			
				8-12 Gray very sandy clay								
	20			12-16 Orange silty sand becoming more gravelly w/ depth								
	25											
	30											
	35											

NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE

D - DRIVE
 C - CORE
 G - GRAB

▼ Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: MPQ/LF6 CONTRACTOR: Parsons ES DATE SPUD: 11/12/96 800
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL.:
 JOB NO.: 729691 DRLG METHOD: Geoprobe ELEVATION: 50 ft
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/8 TEMP:
 GEOLOGIST: DRLG FLUID: - WEATHER: Cloudy-Green
 COMMENTS:

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample		Penet Res	PD(ppm)	ILV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
					No.	Depth (ft)					
90 ⁹	1			0-2 Top soil w/cobble	2			48			
				2-3 Gray silty sand	4			40			
	5			3-4 Gray silty Clay - brittle	6			38			
100 ⁵				4-8 Gray sandy tight clay Becoming wet at 7'	8			31			
	10				10			28			
					12			35			
100 ⁵				8-15 Gray sandy clay (sand increasing w/depth to a very sandy clay at 12')	14			40			
	15				16			35			
				15-16 Gray slightly sandy clay							
	20										
	25										
	30										
	35										

NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE

D - DRIVE
 C - CORE
 G - GRAB



Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: LF06-MPR CONTRACTOR: PARSONS ES DATE SPUD: 11/14/96
 CLIENT: AFCEE RIG TYPE: Coresprobe DATE CMPL.: 11/14/96
 JOB NO.: 729691 DRLG METHOD: Geoprobe ELEVATION: GS
 LOCATION: COLUMBUS AFB BORING DIA.: 2 1/8" TEMP: 60-65°F
 GEOLOGIST: B. Henry DRLG FLUID: NA WEATHER: Clear-Sunny
 COMMENTS: C. Snyder

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	Ambient RAD(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
0-4' 3'R (75%)	1		CL	0-4' CLAY - gray, mottled red-brown, stiff to soft, silty in part, plastic, v. moist	1322		D		27	0.0		
4-7' 4'R (100%)	5		CL	0-7' CLAY-AA			D		28	0.0		
7-10' 3'R (100%)				7-10' SILTY CLAY - H. gray, mottled orange-brown, stiff- firm, very silty in part, moist			D		30.4	0.0		
			CL	10-11' SILTY CLAY-AA. becoming incr silty - sandy, U. moist			D					
	10		SC	11-12.5 SAND - gray f-cvs gr, to gravel up to 1", v. poorly - mod. sorted, loose, silty, some clay mtx, v. moist-wet			D		29.0	0.0		
				12.5-14' SAND. gray, f-cvs grained, mod sorted, trace clay & silt matrix, wet, loose, no odor			D		10.0	0.0		
	15		SC									
	20											
	25											
	30											
	35											

WATER ~ 11'

SET 3' PrePack 1/2" PVC
10-6104 Screen at 13-16

NOTES

bgs - Below Ground Surface
 GS - Ground Surface
 TOC - Top of Casing
 NS - Not Sampled
 SAA - Same As Above

SAMPLE TYPE

D - DRIVE
 C - CORE
 G - GRAB



Water level drilled

FIGURE 3.4

GEOLOGIC BORING LOG

Sites ST-24 and LF-06
 Intrinsic Remediation TS
 Columbus AFB, Mississippi

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

APPENDIX A-2
MONITORING POINT DEVELOPMENT FORMS

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB/LF6

by RN/JH/CS/BL

Date: 11/17, 1996

Well Number MPA(S)

Measurement Datum TOC

Pre-Development Information

Time (Start): 237

Water Level: 3.1

Total Depth of Well: 13.7

Water Characteristics

Color Black

Clear Cloudy

Odor: None

Weak

Moderate Strong

Pickle

Any Films or Immiscible Material -

pH 6.90

Temperature(°C) 20.2

Specific Conductance(μS/cm) 805

Dissolved Oxygen (mg/L) 0.40

Redox -75

Interim Water Characteristics

Gallons Removed 0.75

Time 254

pH 6.89

Temperature (°C) 20.3

Specific Conductance(μS/cm) 832

Dissolved Oxygen (mg/L) 0.11

Redox -84

Post-Development Information

Time (Finish): 3:30

Water Level: _____

Total Depth of Well: _____

Approximate Volume Removed: _____

Water Characteristics

Color slightly

Clear Cloudy

Odor: None

Weak

Moderate Strong

Any Films or Immiscible Material _____

pH 6.77

Temperature(°C) 20.3

Specific Conductance(μS/cm) 824

Dissolved Oxygen (mg/L) 0.62

Comments: Redox -103

$$\begin{array}{r} 13.7 \\ 3.1 \\ \hline 10.6 / 10 = 1.06 \text{ gallons} \end{array}$$

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFC EE-RNA

Location Columbus AFB, LF6

by RN/JH/CS/BL Date: 11/17, 1996

Well Number LF6-MPB

Measurement Datum TOC

Pre-Development Information

Time (Start): 150

Water Level: 9.4

Total Depth of Well: 11.4

Water Characteristics

Color Dark brown Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 5.00 Temperature(°C) 19.8
Specific Conductance(μS/cm) 491
Dissolved Oxygen (mg/L) 1.24
Redox 0.5

Interim Water Characteristics

Allow to recharge 1:57 -

Gallons Removed _____

pH _____

Temperature (°C) _____

Specific Conductance(μS/cm) _____

Dissolved Oxygen (mg/L) _____

Redox

Post-Development Information

Time (Finish): _____

Water Level: _____

Total Depth of Well: _____

Approximate Volume Removed: _____

Water Characteristics

Color _____ Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material _____
pH _____ Temperature(°C) _____
Specific Conductance(μS/cm) _____
Dissolved Oxygen (mg/L) _____

Comments:

Redox

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, LF6

by RN/JH/CS/BL

Date: 11/17, 1996

Well Number LF6-MPC(5)

Measurement Datum TOC

Pre-Development Information

Time (Start): 754

Water Level: 19.8

Total Depth of Well: 22.2

Water Characteristics

Color Brown Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material -
 pH 7.22 Temperature(°C) 17.4
 Specific Conductance(μS/cm) 545
 Dissolved Oxygen (mg/L) 2.55
Redox -64

Interim Water Characteristics

Gallons Removed 0.3

Time 810

pH 6.63

Temperature (°C) 17.3

Specific Conductance(μS/cm) 512

Dissolved Oxygen (mg/L) 2.56

Redox -66

Post-Development Information

Time (Finish): 840

Water Level:

Total Depth of Well:

Approximate Volume Removed:

0.5

Water Characteristics

Color Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material -
 pH 6.48 Temperature(°C) 17.1
 Specific Conductance(μS/cm) 491
 Dissolved Oxygen (mg/L) 1.94

Comments:

Redox -44

$$\begin{array}{r} 22.2 \\ - 19.8 \\ \hline 2.4 \end{array} / 10 = 0.24 \text{ gallons}$$

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFC EE-RNA

Location Columbus AFB, LF6

by RN/JH/CS/BL

Date: 11/17, 1996

Well Number

MPCED

Measurement Datum

Pre-Development Information

Time (Start): 915

Water Level: ~20

Total Depth of Well:

Water Characteristics

Color Brown Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 7.16 Temperature(°C) 16.3
Specific Conductance(μS/cm) 260
Dissolved Oxygen (mg/L) 1.73

Redox 60

Interim Water Characteristics

Gallons Removed 1

Time 9:35

pH 5.22

Temperature (°C) 17.6

Specific Conductance(μS/cm) 184

Dissolved Oxygen (mg/L) 0.42

Redox -173

Post-Development Information

Time (Finish): 1011

Water Level:

Total Depth of Well:

Approximate Volume Removed: 2g

Water Characteristics

Color Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 5.39 Temperature(°C) 17.8
Specific Conductance(μS/cm) 177
Dissolved Oxygen (mg/L) 0.63

Comments:

Redox -300

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, ST24

by RN/JH/CS/BL RM Date: 11/17, 1996

Well Number LF06 - M PDS

Measurement Datum Top of well PVC

Pre-Development Information

Time (Start): 1420

Water Level: 18.0 Total Depth of Well: 15.77

TOP OF WELL PVC PIPE

Water Characteristics

Color Brown Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material None
pH NR Temperature (°C) NR
Specific Conductance (µS/cm) NR
Dissolved Oxygen (mg/L) NR

Interim Water Characteristics

Well purged dry immediately,
never recovered (waited 20 min.)

Gallons Removed _____

pH _____

NOT SAMPLED

Temperature (°C) _____

Specific Conductance (µS/cm) _____

Dissolved Oxygen (mg/L) _____

Post-Development Information

Time (Finish): _____

Water Level: _____

Total Depth of Well: _____

Approximate Volume Removed: _____

Water Characteristics

Color _____ Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material _____
pH _____ Temperature (°C) _____
Specific Conductance (µS/cm) _____
Dissolved Oxygen (mg/L) _____

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, ST24

by RN/JH/CS/BL BMLH Date: 11/17, 1996

Well Number LF06 - MPDB

Measurement Datum NA

Pre-Development Information

Time (Start): 1340

Water Level: NA

Total Depth of Well: ~31.5' as installed

Water Characteristics

Color Brown

Clear Cloudy

Odor: None

Weak

Moderate

Strong

Any Films or Immiscible Material None

pH 5.12 Temperature(°C) 18.0

Specific Conductance(μS/cm) 130

Dissolved Oxygen (mg/L) 0.52

Interim Water Characteristics

Time	1342	1348	1352	1358
Gallons Removed	0.1	0.5	1.0	2.0
pH	5.12	5.11	5.09	5.05
Temperature (°C)	18.0	18.0	18.0	18.0
Specific Conductance(μS/cm)	130	165	150	140
Dissolved Oxygen (mg/L)	0.52	0.34	0.26	0.18
Redox (mv)	89	87.5	88.9	92.6

Post-Development Information

Time (Finish): 1358

Water Level: NA

Total Depth of Well: ~31.5'

Approximate Volume Removed: 2.0+ gal.

Water Characteristics

Color sl. Cloudy

Clear Cloudy

Odor: None

Weak

Moderate

Strong

Any Films or Immiscible Material None

pH 5.05

Temperature(°C) 18.0°C

Specific Conductance(μS/cm) 140

Dissolved Oxygen (mg/L) 0.17

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, ST24

by RN/JH/CS/BL Bml Date: 11/12 1996

Well Number LFOC - MPF (S)

Measurement Datum Top Pk

Pre-Development Information

Time (Start): 0850

Water Level: 2.48' TPV

Total Depth of Well: 12.9' TPV

Water Characteristics

Color brown Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material None
 pH 6.20 Temperature(°C) 17.9
 Specific Conductance(μS/cm) 800
 Dissolved Oxygen (mg/L) 0.40

Interim Water Characteristics

Time	0900	0908	0915
Gallons Removed	1.0	2.0	3.0
pH	6.19	6.21	6.24
Temperature (°C)	17.8	17.6	17.6
Specific Conductance(μS/cm)	810	790	800
Dissolved Oxygen (mg/L)	0.35	0.35	0.34
	-115.6	-104.3	-107.3

Post-Development Information

Time (Finish): 0915

Water Level: NR

Total Depth of Well: 12.9'

Approximate Volume Removed: 3.0 gallons

Water Characteristics

Color Tinted yellow Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material None
 pH 6.24 Temperature(°C) 17.6
 Specific Conductance(μS/cm) 800
 Dissolved Oxygen (mg/L) 0.34

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, ST24

by RN/HH/CS/BL BMH Date: 11/17, 1996

Well Number LF06-MPF-D

Measurement Datum NA

Pre-Development Information

Time (Start): 1610

Water Level: NA

Total Depth of Well: NA (~30')

Water Characteristics

Color Brown Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material None
 pH 6.34 Temperature(°C) 18.7
 Specific Conductance(μS/cm) _____
 Dissolved Oxygen (mg/L) 0.58

Interim Water Characteristics

Time	1625	1635	1650
Gallons Removed	0.3	0.6	1.0
pH	6.37	6.49	6.48
Temperature (°C)	18.6	18.4	18.4
Specific Conductance(μS/cm)	750	600	620
Dissolved Oxygen (mg/L)	0.45	2.55*	2.11*
Redox (mv)	11.2	-13.7	-15.0

→ Sample 1650

* Sucking Air

Post-Development Information

Time (Finish): 1650

Water Level: NA

Total Depth of Well: NA

Approximate Volume Removed: 1.0 gal.

Water Characteristics

Color Clear w/ yellow tint Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material None
 pH 6.48 Temperature(°C) 18.4°C
 Specific Conductance(μS/cm) 620
 Dissolved Oxygen (mg/L) 2.11

Comments:

water

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, ST24

by RN/JH/CS/BLR m14 Date: 11/18, 1996

Well Number LE06-MPG

Measurement Datum Top PVC

Pre-Development Information

Time (Start): 0700

Water Level: 14.87' TPC

Total Depth of Well: 16.9' TAC

Water Characteristics

Color Gray Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material None
pH 6.59 Temperature(°C) 17.8
Specific Conductance(μS/cm) 90
Dissolved Oxygen (mg/L) 7.04

Interim Water Characteristics

Gallons Removed 0.3*

pH 6.32

Temperature (°C) 17.6

Specific Conductance(μS/cm) 89

Dissolved Oxygen (mg/L) 7.10

Post-Development Information

Time (Finish): 0740

Water Level: NR - Bailed dry

Total Depth of Well: 16.9

Approximate Volume Removed: 0.6 gal.

Water Characteristics

Color Gray sl. Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material None
pH 6.48 Temperature(°C) 17.7
Specific Conductance(μS/cm) 110
Dissolved Oxygen (mg/L) 6.90

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCCE-RNA

Location Columbus AFB, LF6

by RN/JH/CS/BL

Date: 11/15, 1996

Well Number LF6-MPH

Measurement Datum TOC (still sticking up)

Pre-Development Information

Time (Start): 955

Water Level: 8.85

Total Depth of Well: 14.1

Water Characteristics

Color brown

Clear ☒ Cloudy

Odor: ☒ None

Weak

Moderate

Strong

Any Films or Immiscible Material -

pH 5.41

Temperature(°C) 18.3

Specific Conductance(μS/cm) 78

Dissolved Oxygen (mg/L) 5.09

Redox 75

Interim Water Characteristics

Gallons Removed 0.5

Time=1027

Allowed well to recharge from 1000 to 1022

pH 6.35

Temperature (°C) 19.1

Specific Conductance(μS/cm) 81

Dissolved Oxygen (mg/L) 4.54

Redox 50

Post-Development Information

Time (Finish): 1044

Water Level:

Total Depth of Well: 14.1

Approximate Volume Removed: 1.5

Water Characteristics

Color

☒ Clear ☐ Cloudy

Odor: ☒ None

Weak

Moderate

Strong

Any Films or Immiscible Material -

pH 5.28

Temperature(°C) 19.9

Specific Conductance(μS/cm) 81

Dissolved Oxygen (mg/L) 4.63

Comments:

$$\begin{array}{r} 14.1 \\ - 8.8 \\ \hline 5.3 \times 0.1 = 0.53 \text{ gallons to develop} \end{array}$$

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, LF6

by RN/JH/CS/BL

Date: 1996

Well Number LF6-MPI

Measurement Datum TDC (still striking up)

Pre-Development Information

Time (Start): 1420

Water Level: 13.2

Total Depth of Well: 23.7'

Water Characteristics

Color brown Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 5.85 Temperature(°C) 20.4
Specific Conductance(μS/cm) 287
Dissolved Oxygen (mg/L) 2.07
Redox 61

Interim Water Characteristics

Gallons Removed 0.8 gallons

time 436

pH 5.43

Temperature (°C) 20.9

Specific Conductance(μS/cm) 241

Dissolved Oxygen (mg/L) 0.45

Redox 104

Post-Development Information

Time (Finish): 5:00

Water Level: _____

Total Depth of Well: _____

Approximate Volume Removed: 2.5 gallons

Water Characteristics

Color Slightly Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 5.10 Temperature(°C) 20.8
Specific Conductance(μS/cm) 230
Dissolved Oxygen (mg/L) 0.20

Comments: Redox 114

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCCE-RNA

Location Columbus AFB, LF6

by RN/JH/CS/BL Date: 11/17, 1996

Well Number LF6-MPJ

Measurement Datum _____

Pre-Development Information

Time (Start): Pumping 1100 / Measure 1109

Water Level: _____

Total Depth of Well: _____

Water Characteristics

Color brown-orange Clear cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 6.45 Temperature(°C) 17.7
Specific Conductance(μS/cm) 203
Dissolved Oxygen (mg/L) 3.66
Redox

Interim Water Characteristics

Gallons Removed 1 Liter 1156
pH 5.97
Temperature (°C) 18.8
Specific Conductance(μS/cm) 160
Dissolved Oxygen (mg/L) 5.37
Redox -5

Post-Development Information

Time (Finish): 12:

Water Level: _____

Total Depth of Well: _____

Approximate Volume Removed: 0.8 Gallons

Water Characteristics

Color - Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 5.68 Temperature(°C) 19.9
Specific Conductance(μS/cm) 129
Dissolved Oxygen (mg/L) 2.82

Comments: Redox -60

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, LF6

by RN/JH/CS/BL

Date: 11/15, 1996

Well Number LF6-MPK

Measurement Datum TOC

Pre-Development Information

Time (Start): 318

Water Level: 14.0

Total Depth of Well: 16.5

Water Characteristics

Color Brown Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 6.20 Temperature(°C) 20.2
Specific Conductance(μS/cm) 502
Dissolved Oxygen (mg/L) 0.93
Redox -0.7

Interim Water Characteristics

Gallons Removed 0.3
pH 6.30
Temperature (°C) 20.6
Specific Conductance(μS/cm) 516
Dissolved Oxygen (mg/L) 0.62
Redox -0.6

Post-Development Information

Time (Finish): 345

Water Level: _____

Total Depth of Well: _____

Approximate Volume Removed: 2.5 gallons

Water Characteristics

Color Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 6.18 Temperature(°C) 20.5
Specific Conductance(μS/cm) 504
Dissolved Oxygen (mg/L) 0.18
Redox -1.0

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, LF6

by RN/JH/CS/BL

Date: 11/15, 1996

Well Number LF6-MPR

Measurement Datum TOC sticking up still

Pre-Development Information

Time (Start): 1140

Water Level: 11.75 (TOC)

Total Depth of Well: 17.10 (TOC)

11.35 (BLS)

16.70 (BLS)

Water Characteristics

Color very cloudy red-brown Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material -
 pH 6.30 Temperature(°C) 20.5
 Specific Conductance(μS/cm) 247
 Dissolved Oxygen (mg/L) 0.63
 Redox 62

Interim Water Characteristics

Gallons Removed 0.5 gallons Time = 11:54
 pH 6.30 5.84
 Temperature (°C) 20.4
 Specific Conductance(μS/cm) 268
 Dissolved Oxygen (mg/L) 0.71
 Redox 41

Post-Development Information

Time (Finish): 1204

Water Level: _____

Total Depth of Well: 17.10

Approximate Volume Removed: 1 gallon

Water Characteristics

Color Slightly Cloudy Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material -
 pH 5.67 Temperature(°C) 20.5
 Specific Conductance(μS/cm) 268
 Dissolved Oxygen (mg/L) 0.28

Comments:

Relax 46.

$$\begin{array}{r} 17.10 \\ 11.75 \\ \hline 5.35 \times 1.10 = 0.53 \text{ gallon} \end{array}$$

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, LF6

by RM/JH/CS/BL Date: 11/13/ 1996

Well Number LF6-MPM

Measurement Datum TDC

Pre-Development Information

Time (Start): 335 pm

Water Level: 12.5'

Total Depth of Well: 18.5'

Water Characteristics

Color brown Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 5.59 Temperature(°C) 17.9
Specific Conductance(μS/cm) 79
Dissolved Oxygen (mg/L) 5.90

Interim Water Characteristics

Gallons Removed 0.5 1600 = time
pH 5.53
Temperature (°C) 18.7
Specific Conductance(μS/cm) 62
Dissolved Oxygen (mg/L) 6.96

Post-Development Information

Time (Finish): 1613

Water Level: 12.5'

Total Depth of Well: 18.5'

Approximate Volume Removed: 1.25 gallons

Water Characteristics

Color slightly gray Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 5.48 Temperature(°C) 19.1
Specific Conductance(μS/cm) 61
Dissolved Oxygen (mg/L) 6.18

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, LF6

by RN/JH/CS/BL

Date: 11/17, 1996

Well Number LF6-MPN

Measurement Datum TOC

Pre-Development Information

Time (Start): 655

Water Level: 20.2

Total Depth of Well: 23.6

Water Characteristics

Color Brown

Clear Cloudy

Odor: None

Weak

Moderate

Strong

Any Films or Immiscible Material -

pH 6.60

Temperature(°C) 17.2

Specific Conductance(μS/cm) 13

Dissolved Oxygen (mg/L) 1.35

Redox 151

Interim Water Characteristics

Gallons Removed 0.5

Time 706

pH 6.75

Temperature (°C) 18.0

Specific Conductance(μS/cm) 597

Dissolved Oxygen (mg/L) 1.02

Redox -55

Post-Development Information

Time (Finish): 7

Water Level: _____

Total Depth of Well: _____

Approximate Volume Removed: 3.4 gallons

Water Characteristics

Color Clear

Cloudy

Odor: None

Weak

Moderate

Strong

Any Films or Immiscible Material -

pH 6.77

Temperature(°C) 18.3

Specific Conductance(μS/cm) 599

Dissolved Oxygen (mg/L) 0.33

Redox -54

Comments:

$$\begin{array}{r} 23.6 \\ - 20.2 \\ \hline 3.4 / 10 = 0.34 \text{ gallons} \end{array}$$

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFC EE-RNA

Location: Columbus AFB, LF6

by: RN/JH/CS/BL

Date: 11/14, 1996

Well Number: MPO

Measurement Datum: Ground surface

Pre-Development Information

Time (Start): 710

Water Level: DTW = 4.5'

Total Depth of Well: 14.5'

Water Characteristics

Color: Slightly cloudy gray Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material: -
pH: 4.83 Temperature (°C): 17.8
Specific Conductance (µS/cm): 672
Dissolved Oxygen (mg/L): 1.18

Interim Water Characteristics

Gallons Removed: 1 Time: 7:16
pH: 4.75
Temperature (°C): 18.5
Specific Conductance (µS/cm): 86.6
Dissolved Oxygen (mg/L): 0.46

Post-Development Information

Time (Finish): 725

Water Level: can't measure w/ tube in point Total Depth of Well: 14.5

Approximate Volume Removed: 1.8 gall

Water Characteristics

Color: Slightly gray Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material: -
pH: 4.80 Temperature (°C): 18.8
Specific Conductance (µS/cm): 86.0
Dissolved Oxygen (mg/L): 0.27

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, LF6

by RN/JH/CS/BL

Date: 11/14, 1996

Well Number LF6-MPP

Measurement Datum Ground Surface

Pre-Development Information

Time (Start): 0850

Water Level: 5.3'

Total Depth of Well: 13.7'

Water Characteristics

Color ORANGE BROWN Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material _____
pH 5.67 Temperature(°C) 17.2
Specific Conductance(μS/cm) 355
Dissolved Oxygen (mg/L) 4.02

Interim Water Characteristics

Gallons Removed 0.6
pH 5.13
Temperature (°C) 18.3
Specific Conductance(μS/cm) 239
Dissolved Oxygen (mg/L) 0.93

Post-Development Information

Time (Finish): 0905

Water Level: _____

Total Depth of Well: _____

Approximate Volume Removed: _____

Water Characteristics

Color lt. suspended solids Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material _____
pH 4.89 Temperature(°C) 18.6
Specific Conductance(μS/cm) 218
Dissolved Oxygen (mg/L) 4.03 0.48

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFC EE-RNA

Location Columbus AFB, LF6

by RM/JH/CS/BL

Date: 11/14, 1996

Well Number MPQ (LF6)

Measurement Datum T0C

Pre-Development Information

Time (Start): 1540

Water Level: 4.2

Total Depth of Well: 14.0

Water Characteristics

Color Slightly cloudy Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material -
pH 6.01 Temperature(°C) 18.0
Specific Conductance(μS/cm) 758
Dissolved Oxygen (mg/L) 4.28

Interim Water Characteristics

Time = 1612

Gallons Removed 0.75

pH 6.00

Temperature (°C) 18.0

Specific Conductance(μS/cm) 581

Dissolved Oxygen (mg/L) 4.31

Post-Development Information

Time (Finish):

Water Level:

Total Depth of Well:

Approximate Volume Removed:

Water Characteristics

Color _____ Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material _____
pH _____ Temperature(°C) _____
Specific Conductance(μS/cm) _____
Dissolved Oxygen (mg/L) _____

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020

Job Name: AFCEE-RNA

Location Columbus AFB, ST24

by RN/JH/CS/BL Bmt Date: 11/17/1996

Well Number LFOG-MPR

Measurement Datum Top PVC

Pre-Development Information

Time (Start): 1220

Water Level: 4.42' TPVC

Total Depth of Well: 14.7' TPVC

Water Characteristics

Color Brown Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material None
 pH 5.12 Temperature(°C) 19.4°C
 Specific Conductance(μS/cm) 650
 Dissolved Oxygen (mg/L) 0.65

DWL-TD = 10.28'

Casing Vol. = 0.105 gal.

10 x CV = 1.05 gal.

Interim Water Characteristics

Time	1225	1230	1235	1240
Gallons Removed	0.5	1.0	1.5	2.0
pH	5.10	5.15	5.02	5.01
Temperature (°C)	19.2	19.2	19.2	19.2
Specific Conductance(μS/cm)	650	700	720	700
Dissolved Oxygen (mg/L)	0.61	0.64	0.21	0.16
Redox	133	76.4	66.8	64.3

Post-Development Information

Time (Finish): 1240

Water Level: NR

Total Depth of Well: 14.7' PVC

Approximate Volume Removed: 2.0 gal.

Water Characteristics

Color Clear Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material None
 pH 5.01 Temperature(°C) 19.2°C
 Specific Conductance(μS/cm) 700
 Dissolved Oxygen (mg/L) 0.15

Comments:

APPENDIX A-3
GROUNDWATER SAMPLING FORMS

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL W18

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/15/96, 1996 1500 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: _____

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC 17.55
GS surface 14.4

MONITORING WELL CONDITION:

☒ LOCKED:

☐ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: good

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe): _____

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH isopropanol and distilled water
Items Cleaned (List): Probes

2 ☐

PRODUCT DEPTH _____ FT. BELOW DATUM
Measured with: _____

WATER DEPTH 17.55 (TOC) 14.40 (BLS) FT. BELOW DATUM
Measured with: Selinst

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: cloudy → slightly cloudy

Odor: _____

Other Comments: Lime clogged initially and water was cloudy brown but after clogging water cleaned

4 ☐

WELL EVACUATION

Method: Peristaltic pump

Volume Removed: _____

Observations: Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors: _____

Other comments: _____

TD 37.0
DTW 14.5

$22.5 / 2 = 11.25$ ~~gallons~~ gallons

Groundwater Sampling Record

Monitoring Well No. W18 (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____

☒ Pump, type: Peristaltic

[] Other, describe: _____

145

15
7

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	1302	1345	1425	1450	1515	Measured with
Temp (°C)	19.7	19.6	19.4	19.3	19.3	YSI SS
pH	5.50	5.66	5.59	5.57	5.57	Orion 250A
Cond (µS/cm)	252	263	258	249	245	Hach Melor
DO (mg/L)	0.71	0.20	0.19	0.17	0.16	YSI SS
Redox (mV)	894	88	94.5	997	100	Orion 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

gallons 0.8 4 8 10 11
SAMPLE CONTAINERS (material, number, size):

10 UOAS
1 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[]

Filtration:

Method _____

Containers: _____

Method _____

Containers: _____

Method _____

Containers: _____

☒

Preservatives added:

Method HCl

Containers: UOAS

Method _____

Containers: _____

Method _____

Containers: _____

Method _____

Containers: _____

9 []

CONTAINER HANDLING:

☒

Container Sides Labeled

☒

Container Lids Taped

☒

Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF012 - W191

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☒ Special Sampling; PN A

DATE AND TIME OF SAMPLING: 11/17/96, 1996 1050 am/p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: Partly Cloudy Partly Rainy - 60°F

DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of PVC

MONITORING WELL CONDITION:

☒ LOCKED:

☐ UNLOCKED

WELL NUMBER (IS) IS NOT APPARENT

STEEL CASING CONDITION IS: Good

INNER PVC CASING CONDITION IS: Good

WATER DEPTH MEASUREMENT DATUM (IS) IS NOT APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH Alconox / DI WATER / Invert-Brake / DI

Items Cleaned (List): Water level Indicator - Not working

2 ☐

PRODUCT DEPTH NA FT. BELOW DATUM

Measured with:

WATER DEPTH 19.5' - measured last week FT. BELOW DATUM

Measured with: T.D. = 31.5 2" PVC - 12' Submersible

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: Clear

Odor: None

Other Comments:

Casing Volume = 2.0 gal.

Purge Volume = 6.0 gal.

4 ☐

WELL EVACUATION:

Method: Portable Pump

Volume Removed: 6.0 gal.

Observations: Water (slightly - very) cloudy Clear

Water level (rose - fell - no change) NR

Water odors: None

Other comments:

Time	Volume	pH	Temp	DO	mv	EC	Comment	Analysis
1008	1.0	-	19.6	2.48	490?	90	Clear	VOCs / BTEX / TPH-G / Petrol
1015	2.0	5.10	19.6	2.35	463?	85	"	Ammonia / Oxidation
	3.0	5.05	19.6	2.28	286	80	"	
1035	4.0	5.15	19.6	2.26	283	82	Clear	
1040	5.0	5.16	19.6	2.27	288	85	"	
1047	6.0	5.18	19.6	2.25	284	85	Clear	

Groundwater Sampling Record

Monitoring Well No. LFG-019 (Cont'd)

5 ☒

SAMPLE EXTRACTION METHOD:

- ☐ Bailer made of: _____
☒ Pump, type: Peristaltic
☐ Other, describe: _____

Sample obtained is ☒ GRAB; ☐ COMPOSITE SAMPLE

6 ☒

ON-SITE MEASUREMENTS:

See Page 1

Time						Measured with
Temp (°C)						
pH						
Cond (µS/cm)						
DO (mg/L)						
Redox (mV)						
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 ☒

SAMPLE CONTAINERS (material, number, size): 10 VOCs w/ HCL
1 x 125 ml Plastic
2 Glass Mason Jars

8 ☒

ON-SITE SAMPLE TREATMENT:

☐ Filtration: NA Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

☐ Preservatives added: All HCL except Amies
Method VOCs Containers: _____
Method BTEX / TVH-G Containers: _____
Method Mutane Containers: _____
Method Amies Containers: _____

9 ☒

CONTAINER HANDLING:

- ☒ Container Sides Labeled
☐ Container Lids Taped
☒ Containers Placed in Ice Chest

10 ☒

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB LF6
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL W20

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/14 1996 1515 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: 65 Clear

DATUM FOR WATER DEPTH MEASUREMENT (Describe): T.O.C.

MONITORING WELL CONDITION:

☒ LOCKED: ☐ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: good

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH isopropanol + distilled water

Items Cleaned (List): probes

2 ☐

PRODUCT DEPTH — FT. BELOW DATUM

Measured with: —

WATER DEPTH 5.3 (3.8 below ground) FT. BELOW DATUM

Measured with: Solinst

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: clear

Odor: none

Other Comments:

4 ☐

WELL EVACUATION:

Method: peristaltic pump

Volume Removed: 10.5 gallons

Observations: Water (slightly) - very cloudy

Water level (rose - fell - no change)

Water odors:

Other comments:

$$\begin{array}{r} 23 \text{ TD} \\ 3.8 \\ \hline 19.2 \\ \hline 19.2 / 2 = 9.6 \text{ gallons} \Rightarrow 10 \end{array}$$

Groundwater Sampling Record

Monitoring Well No. W20 (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
☐ Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Begin purge 1400

Time	1400	1430	1440	1453	1506	Measured with
Temp (°C)	17.9	17.7	17.7	17.6	17.6	YSI SS
pH	4.60	4.57	4.47	4.48	4.48	Orion 250A
Cond (µS/cm)	61	64	63	63	63	Hach Meter
DO (mg/L)	0.99	0.95	0.66	0.63	0.64	YSI SS
Redox (mV)	234	251	302	248	254	Orion 250A
Salinity	11.8					YSI SS
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

10 Jars
2 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____



Preservatives added:

Method HCl Containers: VOAs
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL W21

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;
DATE AND TIME OF SAMPLING: 11/14 1996 1320 a.m./p.m.
SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons EG
WEATHER: _____
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

☒ LOCKED: ☐ UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
☐ MONITORING WELL REQUIRED REPAIR (describe): _____

Check-off

- 1 ☐ EQUIPMENT CLEANED BEFORE USE WITH isopropanol and distilled water
Items Cleaned (List): Probes
- 2 ☐ PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —
- WATER DEPTH 8.5 Previous FT. BELOW DATUM
Measured with: Solinst
- 3 ☐ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: _____
- 4 ☐ WELL EVACUATION:
Method: Peristaltic
Volume Removed: 11.5 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: _____

28 TD
- 6 DTW (Ground surface)
 $22/2 = 11$ gallons

Groundwater Sampling Record

Monitoring Well No. W21 (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS: Began purger 11:55

Time	1202	1226	1250	1302	1315	Measured with
Temp (°C)	17.0	17.1	17.1	17.2	16.9	YSI 55
pH	4.34	4.73	4.76	4.34	4.33	Orion 250A
Cond (µS/cm)	242	244	242	241	240	Hach Meter
DO (mg/L)	0.43	0.28	0.19	0.18	0.17	YSI 55
Redox (mV)	199	204	215	221	215.7	Orion 250A
Salinity	4.5	2.9	2.0	1.7		YSI 55
Nitrate						
Sulfate						
Ferrous Iron						

7 []

9 allons 1.0 4 7 9
 SAMPLE CONTAINERS (material, number, size):

10 VOAs
2 Poly
1 Glass Amber

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

☒ Preservatives added:

Method HCl Containers: VOAs
 Method Sulfuric Containers: Glass amber
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL W-22
(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;
DATE AND TIME OF SAMPLING: 11/13/ 1996 1750 a.m. (p.m.)
SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES
WEATHER: SS Cloudy
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

☒ LOCKED: ☐ UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐ EQUIPMENT CLEANED BEFORE USE WITH ISOPROPANOL + distilled water
Items Cleaned (List):

2 ☐ PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 10.15 FT. BELOW DATUM
Measured with: Solinst water level indicator

3 ☐ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly gray
Odor: none
Other Comments:

4 ☐ WELL EVACUATION:
Method: Peristaltic pump
Volume Removed:
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors:
Other comments:

DTW (from ground)	TD (from ground)
7.5	21.5

$$\frac{14}{2} = 7 \text{ gallons}$$

Groundwater Sampling Record Monitoring Well No. W22 (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	1658	1713	1727	1734	1745	Measured with
Temp (°C)	19.5	20.2	20.2	20.1	20.2	YSI 53
pH	4.72	4.65	4.69	4.68	4.63	Orion 250A
Cond (µS/cm)	74	65	64	63	62	Hach meter
DO (mg/L)	0.95	0.51	0.53	0.55	0.51	YSI 55
Redox (mV)	283	207	269	172	175	Orion 250A
Salinity	10.1	6.0	5.7	6.2	6.2	YSI 55
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

gallons 1 3 5 6
10 VOAS
2 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:

Method HCl Containers: VOAS
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

W1 is duplicate
time labeled at 630pm

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB (LF6)
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL W78 (number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;
DATE AND TIME OF SAMPLING: 11/14 1996 1110 a.m. p.m.
SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES
WEATHER: 62° Cloudy
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

☒ LOCKED: ☐ UNLOCKED
WELL NUMBER (IS) IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS) IS NOT) APPARENT
☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

- 1 ☐ EQUIPMENT CLEANED BEFORE USE WITH Isopropanol and Distilled Water
Items Cleaned (List): Probes
- 2 ☐ PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —
- WATER DEPTH 8.1 previous FT. BELOW DATUM
Measured with: Solinst
- 3 ☐ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: none
Other Comments: —
- 4 ☐ WELL EVACUATION:
Method: Peristaltic
Volume Removed: 1 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: —

Groundwater Sampling Record
Monitoring Well No. W78 (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS: Begin purge at 1010

Time	1013	1024	1035	1051	110	Measured with
Temp (°C)	17.9	18.3	18.4	18.7	18.7	YSI 55
pH	4.51	4.55	4.47	4.65	4.48	Orion 250A
Cond (µS/cm)	158	182	189	199	198	Hach Meter
DO (mg/L)	0.73	0.54	0.45	0.30	0.29	YSI 55
Redox (mV)	139.3	158.2	163.0	185	184	Orion 250A
Salinity	7.1	5.8	4.8	3.1	3.2	YSI 55
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

0.5 gallon 2 gallons 3 gallons 5 gallon
10 VOAs
2 Poly
1 Glass amber

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:
 Method HCl Containers: VOAs
 Method Sulfuric Containers: Glass amber
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

Duplicate W2
TUH and VOAs only

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - KF6
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL

W79

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/15, 1996 745 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CSRN of Parsons ES

WEATHER: 55° Clear

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

☒ LOCKED:

☐ UNLOCKED

WELL NUMBER (IS) IS NOT) APPARENT

STEEL CASING CONDITION IS: good

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS) IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH isopropyl alcohol +

Items Cleaned (List): probes

2 ☐

PRODUCT DEPTH — FT. BELOW DATUM

Measured with: —

WATER DEPTH 8.9 (TOC) 5.9 (BLS) FT. BELOW DATUM

Measured with: Solinst

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: cloudy brown

Odor: none

Other Comments:

4 ☐

WELL EVACUATION:

Method: Peristaltic Pump

Volume Removed:

Observations: Water (slightly) - very) cloudy

Water level (rose - fell - no change)

Water odors: none

Other comments:

$$\begin{array}{r} 20 \\ - 6 \\ \hline 14 \end{array} \div 2 = 7 \text{ gallons}$$

Groundwater Sampling Record

Monitoring Well No. A79 (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	650	707	713	725	735	Measured with
Temp (°C)	17.3	17.4	17.3	16.9	16.9	YSI 55
pH	3.55	4.57	4.42	4.59	4.65	Orion 250A
Cond (µS/cm)	47	45	45	44	44	Hach Meter
DO (mg/L)	3.25	3.33	2.91	3.05	2.88	YSI 55
Redox (mV)	147	156	166	170	181	Orion 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

gal 2 4 5 6
10 VOAs
2 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

☒ Preservatives added:

Method HCl Containers: VOAs
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL W81 (LF6)

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/13, 1996 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CSRN of Parsons ES

WEATHER: 60° Overcast

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

[] LOCKED:

UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: Good

INNER PVC CASING CONDITION IS: GOOD

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

[] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

[] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 []

EQUIPMENT CLEANED BEFORE USE WITH Isopropanol and distilled water

Items Cleaned (List): Probes

2 []

PRODUCT DEPTH _____ FT. BELOW DATUM

Measured with.

WATER DEPTH 6.5 FT. BELOW DATUM

Measured with: Solinst water level indicator previously

3 []

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: cloudy brown

Odor: none -

Other Comments:

4 []

WELL EVACUATION:

Method: Peristaltic

Volume Removed: 2 gallons

Observations: Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors: none

Other comments:

Groundwater Sampling Record

Monitoring Well No. W81 (LFG) (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: _____
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

1427

Time	1427	1435	1440	1444		Measured with
Temp (°C)	19.8	20.0	20.0	20.0		YSI 55
pH	6.12	6.16	6.15	6.16		Orion 280A
Cond (µS/cm)	653	624	620	624		Hach meter
DO (mg/L)	0.33	0.23	0.23	0.20		YSI 55
Redox (mV)	-48	-61.1	-63.0	-64.6		Orion 280A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron	0.5	1.0	1.5	2.0		

gallons

7 []

SAMPLE CONTAINERS (material, number, size):

10 VOAS

1 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:

Method HCl Containers: VOAS
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL W82
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [] Special Sampling;
DATE AND TIME OF SAMPLING: 11/15 1996 1000 a.m./p.m.
SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES
WEATHER: 60° breezy, sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): _____

MONITORING WELL CONDITION:

[] LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT _____
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT _____
[] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[] MONITORING WELL REQUIRED REPAIR (describe): _____

Check-off

- 1 [] EQUIPMENT CLEANED BEFORE USE WITH Isopropanol + distilled water
Items Cleaned (List): Probes
- 2 [] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —
- WATER DEPTH 9.26 Previous FT. BELOW DATUM
Measured with: Solinst w/ indicator
- 3 [] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: slightly cloudy - brown
Odor: none
Other Comments: —
- 4 [] WELL EVACUATION:
Method: Peristaltic pump
Volume Removed: 8 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: _____

$$\begin{array}{r} 24.4 \\ 9.3 \\ \hline 15.1 / 2 = 7.5 \text{ gallons} \end{array}$$

Monitoring Well No. W82 (Cont'd)

5 []

☐ Bailer made of: _____
☒ Pump, type: Peristaltic
☐ Other, describe: _____

6 []

ON-SITE MEASUREMENTS: *Began purge 820*

Time	834	857	918	925	935	Measured with
Temp (°C)	20.6	20.8	20.7	20.0	20.8	YSI 55
pH	6.98	4.21	4.35	4.64	4.42	Orion 250A
Cond (μS/cm)	60	59	58	58	58	Hach Meter
DO (mg/L)	2.08	2.08	2.06	1.91	2.03	YSI 55
Redox (mV)	186	190	203	227	233	Orion 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

Gallop	2	4	6	7	8
--------	---	---	---	---	---

· 7 []

SAMPLE CONTAINERS (material, number, size):

10 UOAs
2 Poly

8 []

ON-SITE SAMPLE TREATMENT: ...

[] Filtration:

Method	_____	Containers:	_____
Method	_____	Containers:	_____
Method	_____	Containers:	_____

✕

Preservatives added:

Method HCl Containers: VOAs
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

911

CONTAINER HANDLING:

~~Container Sides Labeled~~
~~Container Lids Taped~~
~~Containers Placed in Ice Chest~~

10 [1

OTHER COMMENTS:

GW SAMPLING RECORD MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.32020 Job Name: AFCEE-RNA
 Location Columbus AFB, ST24 by RN/JH/CS/BL BMH Date: 11/18, 1996
 Well Number LFOG - 4F TRNG L W1 Measurement Datum Top PVC

Pre-Development Information

Time (Start): 1030

Water Level: 2.73' TPV Total Depth of Well: 12.77' TPV

Water Characteristics

Color Sl. Cloudy Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material None
 pH 6.27 Temperature(°C) 21.1
 Specific Conductance(μS/cm) 140
 Dissolved Oxygen (mg/L) 3.12
Reox = 320 mv

1 1/2" Diameter Well
 Casing Volume = 0.09 gal
 x 10 CV = 0.92 gal.

Interim Water Characteristics Time

	1040	1044	
Gallons Removed	1.0	(Dry)	
pH	6.04		
Temperature (°C)	20.5		
Specific Conductance(μS/cm)	145		
Dissolved Oxygen (mg/L)	3.08		
<u>Reox</u>	61.2		

- Well Bailed Dry at 1.0 gallons.
- Water Level = 12.70' TPV
- Water level at 10 min. = 12.70' TPV
- Water Not Rising → Dry Well - Did not Sample

Post-Development Information

Time (Finish): _____

Water Level: _____ Total Depth of Well: _____

Approximate Volume Removed: _____

Water Characteristics

Color _____ Clear Cloudy
 Odor: None Weak Moderate Strong
 Any Films or Immiscible Material _____
 pH _____ Temperature(°C) _____
 Specific Conductance(μS/cm) _____
 Dissolved Oxygen (mg/L) _____

Comments:

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6 - 4F82N1W2

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☒ Special Sampling; PNA

DATE AND TIME OF SAMPLING: 11/17/96, 1996 ~~11/17/96~~ Cancel not sample

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES B.M.A.

WEATHER: Cloudy, 60°F

DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top PVC - Highest Point on well

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: OK

INNER PVC CASING CONDITION IS: OK

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☒

EQUIPMENT CLEANED BEFORE USE WITH Acetone / Alconox / Isopropyl / Dist. Water

Items Cleaned (List): Water level Indicator

Precision + Flow Through Cell

2 ☒

PRODUCT DEPTH NA FT. BELOW DATUM

Measured with:

WATER DEPTH 7.35' TPVC / TD = 14.6' TPVC / 1 1/2" PVC FT. BELOW DATUM

Measured with: Sealed Water level Indicator

3 ☒

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: Clear

Odor: None

Other Comments:

4 ☒

WELL EVACUATION:

Method: Peristaltic Pump

Volume Removed: 3.0+ gal.

Observations: Water (slightly - very) cloudy Clear

Water level (rose - fell - no change)

Water odors: None

Other comments:

NOTE:

Bailed Dry, did not recover in 24 hrs, Not Sampled

Groundwater Sampling Record

Monitoring Well No. LFOG-4FBPN- (Cont'd)

SAMPLE EXTRACTION METHOD:

1WZ

- [] Bailer made of: _____
 [x] Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

ON-SITE MEASUREMENTS: → Bailed dry at 1.0 gal.

Volume (gal.) 0.5 1.0 2.0 3.0

Time	<u>1135</u>	<u>1140</u>				Measured with
Temp (°C)	<u>20.8</u>	<u>20.7</u>				<u>YSI 55</u>
pH	<u>5.84</u>	<u>5.70</u>				<u>Orion 280A</u>
Cond (µS/cm)	<u>60</u>	<u>60</u>				<u>YSI</u>
DO (mg/L)	<u>5.50</u>	<u>5.6</u>				<u>YSI 55</u>
Redox (mV)	<u>200</u>	<u>198</u>				
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

SAMPLE CONTAINERS (material, number, size): 10 VOA's / 1 - 125 ml Plastic /
2 Mason Jars

ON-SITE SAMPLE TREATMENT:

- [] NA Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

- [] Preservatives added: — All HCL except Arsenic

Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

CONTAINER HANDLING:

- [x] Container Sides Labeled
 [] Container Lids Taped
 [x] Containers Placed in Ice Chest

OTHER COMMENTS: Bailed dry at 1.0 gal. - Did not Recover
Leave well to sample later

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6-MPA(1)
(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/17/96, 1996 445 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RTD of Parsons ES

WEATHER: 65 Overcast

DATUM FOR WATER DEPTH MEASUREMENT (Describe): —

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS - ~~IS NOT~~) APPARENT

STEEL CASING CONDITION IS: not complete

INNER PVC CASING CONDITION IS: impaired

WATER DEPTH MEASUREMENT DATUM (IS - ~~IS NOT~~) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe): —

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH Distilled water

Items Cleaned (List): Probes

2 ☐

PRODUCT DEPTH — FT. BELOW DATUM

Measured with: —

WATER DEPTH — FT. BELOW DATUM

Measured with: —

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: Cloudy brown

Odor: No. 2

Other Comments: —

4 ☐

WELL EVACUATION:

Method: Peristaltic

Volume Removed: 1.5 gallons

Observations: Water slightly (very) cloudy

Water level (rose - fell - no change)

Water odors: none

Other comments: —

Groundwater Sampling Record Monitoring Well No. LF6-MPA(6) (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

← poured out silty contents of erlenmeyer flask

Time	350	406	416	430	438	Measured with
Temp (°C)	21.0	20.9	20.5	20.2	20.1	YSI 55
pH	5.67	5.77	5.76	5.06	5.67	Orion 250A
Cond (µS/cm)	160	158	150	118	118	Hach Meter
DO (mg/L)	0.39	0.36	0.35	1.38	0.96	YSI 55
Redox (mV)	-297	-280	-238	-60	-67.5	Orion 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

Gallons 0.3 0.4 0.5 0.9 1.1
 SAMPLE CONTAINERS (material, number, size):

1P VOA
1 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____



Preservatives added:

Method HCl Containers: VOAs
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS: very slow pumping!

GROUNDWATER SAMPLING RECORD (1)

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6-MPBB
(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/17 1996 _____ a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: 60° Cloudy

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: Good

INNER PVC CASING CONDITION IS: Good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe): _____

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH Distilled water
Items Cleaned (List): Probes

2 ☐

PRODUCT DEPTH _____ FT. BELOW DATUM
Measured with: _____

WATER DEPTH 9.4 FT. BELOW DATUM
Measured with: Solinst water level indicator

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: _____

Odor: _____

Other Comments: _____

4 ☐

WELL EVACUATION:

Method: Peristaltic

Volume Removed: _____

Observations:

Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors: _____

Other comments: _____

Groundwater Sampling Record Monitoring Well No. LF6-MBB (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is ☒ GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	<u>155</u>					Measured with
Temp (°C)	<u>19.8</u>					<u>YSI SS</u>
pH	<u>5.00</u>					<u>Orion 2SDA</u>
Cond (µS/cm)	<u>493</u>					<u>Hach Meter</u>
DO (mg/L)	<u>1.12</u>					<u>YSI SS</u>
Redox (mV)	<u>0.7</u>					<u>Orion 2SDA</u>
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

10 SAMPLE CONTAINERS (material, number, size): _____
10 VOAs
1 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:
 Method HCl Containers: VOAs
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS: Allow to recharge 157-

GROUNDWATER SAMPLING RECORD (2)

Sampling Location Columbus AFB - LF6
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF06 - MPB (number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☒ Special Sampling; RNA

DATE AND TIME OF SAMPLING: 11/18, 1996 1130 am/p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES Bm4

WEATHER: Cloudy - Raining 60°F

DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top PVC

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (18) IS NOT APPARENT

STEEL CASING CONDITION IS: OK

INNER PVC CASING CONDITION IS: OK

WATER DEPTH MEASUREMENT DATUM (18) IS NOT APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☒

EQUIPMENT CLEANED BEFORE USE WITH Water / Alconox / DI Water

Items Cleaned (List): Water level Indicator

2 ☒

PRODUCT DEPTH N/A FT. BELOW DATUM

Measured with:

WATER DEPTH 4.28' TPC FT. BELOW DATUM

Measured with:

3 ☒

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: Sl. Cloudy - Cleared Quickly

Odor:

Other Comments:

4 ☒

WELL EVACUATION:

Method: Peristaltic Pump

Volume Removed: 1 qt. -> Well Developed Dry day before

Observations: Water (slightly - very) cloudy

Water level (rose - ~~fell~~ - no change)

Water odors: None

Other comments:

Groundwater Sampling Record

Monitoring Well No. LFOe-MPS (Cont'd)

5 [] SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 [] ON-SITE MEASUREMENTS: None - Well Bailed Dry day before, Sample only

Time						Measured with
Temp (°C)						
pH						
Cond (µS/cm)						
DO (mg/L)						
Redox (mV)						
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 [4] SAMPLE CONTAINERS (material, number, size): 10 VOAs w/ HCL
1x 125 ml Plast.
1x Glass Mason Jar

8 [1] ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added: All VOAs HCL
 Method BTEX Containers: _____
 Method TUH-G Containers: _____
 Method VOAs Containers: _____
 Method metals Containers: _____

9 [1] CONTAINER HANDLING:

☒ Container Sides Labeled
 [] Container Lids Taped
☒ Containers Placed in Ice Chest

10 [] OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6-MPC (5)
(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/17/96, 1996 845 a.m/p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: Partly 50°

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER: (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: good

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM: (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐ EQUIPMENT CLEANED BEFORE USE WITH isopropanol + distilled water
Items Cleaned (List): ropes

2 ☐ PRODUCT DEPTH - FT. BELOW DATUM
Measured with: -

WATER DEPTH 19.8 FT. BELOW DATUM
Measured with: Solinst water level indicator

3 ☐ WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: cloudy brown

Odor: none

Other Comments:

4 ☐ WELL EVACUATION:

Method: peristaltic

Volume Removed: 0.5

Observations: Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors: none

Other comments:

Groundwater Sampling Record Monitoring Well No. LF6-MPC(s) (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	807	810	820	830	840	Measured with
Temp (°C)	17.3	17.3	17.1	16.9	17.1	YSI SS
pH	6.67	6.63	6.69	6.79	6.48	Orion 2804
Cond (µS/cm)	519	512	496	500	491	Hach Mder
DO (mg/L)	2.91	2.56	1.66	2.56	2.94	YSI SS
Redox (mV)	-68	-66	-61	-53	-44	Orion 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

gallons 0.25 0.3 40.4 40.5 0.5

7 []

SAMPLE CONTAINERS (material, number, size):

10 VOA's
1 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:

Method HCl Containers: VOA
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

Significant aeration due to little
water in well and slow recharge. Pump is
operating as low as possible while still pumping
water. Aeration decreases at 812
Low volume of water DO probably overestimated

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MPC(D) / LF6
(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/17/96 1996 1015 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: Rain 60°

DATUM FOR WATER DEPTH MEASUREMENT (Describe): estimate from shallow well

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: good

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH Distilled water

Items Cleaned (List): Probes

2 ☐

PRODUCT DEPTH — FT. BELOW DATUM

Measured with: —

WATER DEPTH ~20 FT. BELOW DATUM

Measured with: estimate from LF6-MPC(D)

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: cloudy brown

Odor: —

Other Comments: —

4 ☐

WELL EVACUATION:

Method: Peristaltic

Volume Removed: 2 gallons

Observations: Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors: —

Other comments: —

Groundwater Sampling Record Monitoring Well No. MPCLD (Cont'd)

5 [] SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 [] ON-SITE MEASUREMENTS:

Time	915	928	935	1000	1011	Measured with
Temp (°C)	16.3	17.4	17.6	17.8	17.8	YSI 55
pH	1.16	5.35	5.22	5.48	5.39	Orion 250A
Cond (µS/cm)	260	192	184	181	177	Hach Meter
DO (mg/L)	1.77	0.60	0.42	1.06	0.63	YSI 55
Redox (mV)	60	135	-18	-222.5	-300	Orion 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 [] SAMPLE CONTAINERS (material, number, size):
0.25 15 1 1.5 2
10 VOAs
1 Poly

8 [] ON-SITE SAMPLE TREATMENT:

[] Filtration: Method: _____ Containers: _____
 Method: _____ Containers: _____
 Method: _____ Containers: _____

☒ Preservatives added:
 Method HCl Containers: VOAs
 Method: _____ Containers: _____
 Method: _____ Containers: _____
 Method: _____ Containers: _____

9 [] CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 [] OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - ST24
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF06-MPD (D)
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [] Special Sampling;

DATE AND TIME OF SAMPLING: 11/17, 1996 1410 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: Bmva Cloudy

DATUM FOR WATER DEPTH MEASUREMENT (Describe): NA - Implant

MONITORING WELL CONDITION:

[] LOCKED: [X] UNLOCKED

WELL NUMBER (D) - IS NOT) APPARENT

STEEL CASING CONDITION IS: Good

INNER PVC CASING CONDITION IS: Good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT NA

[] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

[] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☒ EQUIPMENT CLEANED BEFORE USE WITH Arches & Fluorocarbon Cell
Items Cleaned (List): w/ DI water & Alcon

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH NA FT. BELOW DATUM
Measured with:

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly cloudy
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 1.0 gallon
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change) NE
Water odors: None
Other comments:

Groundwater Sampling Record

Monitoring Well No. LFC-100(D) (Cont'd)

SAMPLE EXTRACTION METHOD:

- [] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

ON-SITE MEASUREMENTS:

Vol. (gal.)	2.0	2.5	3.0			
Time	1358	1400	1405			Measured with
Temp (°C)	18.0	18.0	18.0			
pH	5.05	5.04	5.03			
Cond (µS/cm)	140	110	115			
DO (mg/L)	0.18	0.16	0.15			
Redox (mV)	92.6	95.7	96.3			
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

SAMPLE CONTAINERS (material, number, size): 10 VDAs w/ HCl
125 ml Plastic
Glass Mason Jar

ON-SITE SAMPLE TREATMENT:

[] Filtration: NA Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

☒ Preservatives added: All VDAs HCl
 Method BTEX Containers: _____
 Method TU+L Containers: _____
 Method met Containers: _____
 Method DOCs Containers: _____

CONTAINER HANDLING:

- ☒ Container Sides Labeled
 [] Container Lids Taped
☒ Containers Placed in Ice Chest

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - ST24

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LFCX- MPF(S)
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [X] Special Sampling; RNA

DATE AND TIME OF SAMPLING: 11/18, 1996 0430 am/p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: BmH Cloudy - Rainy, 60-65°F

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOP PVC

MONITORING WELL CONDITION:

☒ LOCKED: [] UNLOCKED

WELL NUMBER (IS) IS NOT APPARENT

STEEL CASING CONDITION IS: Good

INNER PVC CASING CONDITION IS: Good

WATER DEPTH MEASUREMENT DATUM (IS) IS NOT APPARENT

[] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

[] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☒ EQUIPMENT CLEANED BEFORE USE WITH Alconox / Isopropyl / DI Water
Items Cleaned (List): Water Level Indicator
Probes & Flow Transducer

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 2.48' TOPVC FT. BELOW DATUM
Measured with: Solinst

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Sl. Cloudy
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 1.5 gal.
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change) NE
Water odors: None
Other comments:

Groundwater Sampling Record

Monitoring Well No. LFCX0-MPF(S) (Cont'd)

SAMPLE EXTRACTION METHOD:

☐ Bailer made of: _____
☒ Pump, type: Peristaltic
☐ Other, describe: _____

Sample obtained is ☒ GRAB; ☐ COMPOSITE SAMPLE

ON-SITE MEASUREMENTS:

Time	0915	0924	0930			Measured with
Temp (°C)	17.6	17.5	17.5			
pH	6.24	6.33	6.32			
Cond (µS/cm)	800	820	820			
DO (mg/L)	0.34	0.19	0.22			
Redox (mV)	-107.3	-130.3	-121.7			
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

SAMPLE CONTAINERS (material, number, size): 10 VOAs w/ HCL
1x 125 ml Plastic
2x Glass Mason Jars

ON-SITE SAMPLE TREATMENT:

☒ Filtration: NA Method _____ Containers: _____
Method _____ Containers: _____
Method _____ Containers: _____

☒ Preservatives added: All VOAs HCL
Method BTEX/TUH-C Containers: _____
Method Methan Containers: _____
Method VOCS Containers: _____
Method Arias Containers: _____

CONTAINER HANDLING:

☒ Container Sides Labeled
☐ Container Lids Taped
☒ Containers Placed in Ice Chest

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF06-MPF(0) (number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/17, 1996 1650 a.m./pm

SAMPLE COLLECTED BY: H/BL/CS/RN of Parsons ES BmH

WEATHER: Cloudy

DATUM FOR WATER DEPTH MEASUREMENT (Describe): NA - Inplant

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER 08 - IS NOT) APPARENT

STEEL CASING CONDITION IS: OK

INNER PVC CASING CONDITION IS: OK

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT NA

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

11

EQUIPMENT CLEANED BEFORE USE WITH Alconox / DI Water

Items Cleaned (List): Probes & Flow Through Cell

211

PRODUCT DEPTH NA FT. BELOW DATUM

Measured with:

WATER DEPTH NA FT. BELOW DATUM

Measured with:

311

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: Slightly Cloudy

Odor: None

Other Comments:

411

WELL EVACUATION:

Method: Peristaltic Pump

Volume Removed: 0.4 gal.

Observations: Water (slightly - very) cloudy

Water level (rose - fell - no change) NA

Water odors: None

Other comments:

Groundwater Sampling Record

Monitoring Well No. LFG0-MPF(D) (Cont'd)

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic Pump
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

ON-SITE MEASUREMENTS:

Vol. (gal)	0.6	1.0				
Time	1635	1650				Measured with
Temp (°C)	18.4	18.4				
pH	6.49	6.48				
Cond (µS/cm)	600	620				
DO (mg/L)	2.55	2.11	→ Sucking Air - Bubbling			
Redox (mV)	-13.7	-15.0				
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

NOTE:

Initial DO = 0.45
 right before bubbling

SAMPLE CONTAINERS (material, number, size): 10 VOAs
125 ml Plastic
1x Glass Mason Jar

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

☒ Preservatives added: All VOAs HCL
 Method BTEX Containers: _____
 Method TU+G Containers: _____
 Method metanol Containers: _____
 Method DOCs Containers: _____

CONTAINER HANDLING:

☒ Container Sides Labeled
 [] Container Lids Taped
☒ Containers Placed in Ice Chest

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - ST24
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LFDG-MPG (number)

REASON FOR SAMPLING: [X] Regular Sampling; ~~[]~~ Special Sampling; RNA

DATE AND TIME OF SAMPLING: 11/18, 1996 0800 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: Bmit Cloudy, Rainy, 60°F

DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top PVC

MONITORING WELL CONDITION:

[] LOCKED:

☒ UNLOCKED

WELL NUMBER ~~(IS)~~ IS NOT APPARENT

STEEL CASING CONDITION IS: Good

INNER PVC CASING CONDITION IS: Good

WATER DEPTH MEASUREMENT DATUM ~~(IS)~~ IS NOT APPARENT

[] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

[] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☒ EQUIPMENT CLEANED BEFORE USE WITH Alconox / Isopropyl / DI Water

Items Cleaned (List): Water Level Indicator

Probes + Flow Through Cell

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM

Measured with:

WATER DEPTH 14.87' FT. BELOW DATUM

Measured with: Solinst

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: Sl. Cloudy

Odor: None

Other Comments:

4 ☒ WELL EVACUATION:

Method: Peristaltic Pump

Volume Removed: 0.4 gal.

Observations: Water ~~(slightly)~~ - very cloudy

Water level (rose - ~~fell~~ no change) → slow recharge

Water odors: None

Other comments:

Groundwater Sampling Record

Monitoring Well No. LF06-MPG (Cont'd)

5 ☒

SAMPLE EXTRACTION METHOD:

☐ Bailer made of: _____
☒ Pump, type: Peristaltic
☐ Other, describe: _____

Sample obtained is ☒ GRAB; ☐ COMPOSITE SAMPLE

6 ☒

ON-SITE MEASUREMENTS:

Vol. (gal.)	0.6	1.0				
Time	0740	0800				Measured with
Temp (°C)	17.7	17.8				
pH	6.48	6.50				
Cond (µS/cm)	110	85				
DO (mg/L)	6.90	7.05				
Redox (mV)	-77.6	-71.3				
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

* Slow Pump -
 Bubbling in
 Flow Line,
 Do not
 representative.

7 ☒

SAMPLE CONTAINERS (material, number, size): 10 VOA's
1x 125 ml. Plastic
2x Glass Mason Jars

8 ☒

ON-SITE SAMPLE TREATMENT:

☐ NA Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

☒ Preservatives added: All VOAs HCL
 Method BTEX Containers: _____
 Method TU14 Containers: _____
 Method UOCs Containers: _____
 Method metals Containers: _____

9 ☒

CONTAINER HANDLING:

☒ Container Sides Labeled
☐ Container Lids Taped
☒ Containers Placed in Ice Chest

10 ☒

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6-MPH (number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/13/96 1996 1100 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons E2

WEATHER: _____

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC (stick up still)

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: Not complete

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe): _____

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH isopropanol and distilled water

Items Cleaned (List): Probes

2 ☐

PRODUCT DEPTH — FT. BELOW DATUM

Measured with: —

WATER DEPTH 8.85 FT. BELOW DATUM

Measured with: Solinst w/l indicator

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: Cloudy brown

Odor: —

Other Comments: —

4 ☐

WELL EVACUATION:

Method: Peristaltic

Volume Removed: 2 gallons

Observations: Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors: none

Other comments: —

Groundwater Sampling Record
Monitoring Well No. LF6MPH (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

*possibly
aerated
due to
air in tubing*

6 []

ON-SITE MEASUREMENTS:

Time	1000	1027	1037	1044	1052	Measured with
Temp (°C)	18.3	19.1	19.9	19.9	19.7	YSI 55
pH	5.41	6.35	5.40	5.28	5.25	Orion 850A
Cond (uS/cm)	78	81	81	81	80	Hach Meter
DO (mg/L)	5.09	4.54	2.96	4.63	5.42	YSI 55
Redox (mV)	75	50	49	54	52	Orion 850A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

0.1 0.5 1 1.5 2
10 JVA
2 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

☒ Preservatives added:

Method HCl Containers: VOAs
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS: at 1000 pump turned off
for well recharge til 1022

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6-MPT

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/15 1996 3:00 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CSRN of Parsons ES

WEATHER: 65° Clear

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC (still sticking up)

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: incomplete

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS ~~IS NOT~~) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH Isopropanol + distilled water
Items Cleaned (List): Probes

2 ☐

PRODUCT DEPTH _____ FT. BELOW DATUM
Measured with: _____

WATER DEPTH _____ FT. BELOW DATUM
Measured with: Solinst water level indicator

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: Cloudy Brown

Odor: none

Other Comments: _____

4 ☐

WELL EVACUATION:

Method: Peristaltic pump

Volume Removed: _____

Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)

Water odors: _____

Other comments: _____

Groundwater Sampling Record

Monitoring Well No. LF6-MPI (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
☐ Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	430	436	445	451	500	Measured with
Temp (°C)	20.7	20.7	20.9	20.9	20.8	YSI 55
pH	5.40	5.43	5.10	5.02	5.10	Orion 256A
Cond (µS/cm)	252	241	234	231	230	Hach Meter
DO (mg/L)	1.20	0.45	0.25	0.21	0.20	YSI 55
Redox (mV)	80	104	111	112	114	Orion 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

0.5 gallon 0.8g 1.8g 1.8
10 UOA
1 Poly
1 Gbl Amber

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:
 Method HCl Containers: UOA
 Method H2SO4 Containers: Glass amber
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6-MPT

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/17, 1996 1:00 a.m. p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: 68° Cloudy

DATUM FOR WATER DEPTH MEASUREMENT (Describe): Ground surface (It's an implant)

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: good

INNER PVC CASING CONDITION IS: implant

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH distilled water

Items Cleaned (List): Probes

2 ☐

PRODUCT DEPTH — FT. BELOW DATUM

Measured with: —

WATER DEPTH — FT. BELOW DATUM

Measured with: —

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: cloudy brown-orange

Odor: none

Other Comments: —

4 ☐

WELL EVACUATION:

Method: Peristaltic

Volume Removed: 0.8 gallons

Observations: Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors: none

Other comments: —

Groundwater Sampling Record

Monitoring Well No. 2 (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	1109	1148	1210	1225	1248	Measured with
Temp (°C)	17.7	18.8	20.2	20.4	19.9	YSI SS
pH	6.45	5.97	5.87	5.62	5.68	Orion 250A
Cond (µS/cm)	203	160	146	138	129	Hach Meter
DO (mg/L)	3.66	5.37	4.10	3.52	2.82	YSI SS
Redox (mV)	-24	-5	-48	-43	-60	Orion 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

250mL 1L 1.25L 1.5L 0.8gallons
10 VOAS
1 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____



Preservatives added:

Method HCl Containers: VOAS
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

Clearing up at about 12:00
slow!

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6-MPK (number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/15, 1996 345 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: 65° Sunny, breeze

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC (still sticking up)

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: Not complete

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐ EQUIPMENT CLEANED BEFORE USE WITH Isopropanol + Distilled Water
Items Cleaned (List): Probes

2 ☐ PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 14.0 FT. BELOW DATUM
Measured with: Solinst water level indicator

3 ☐ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: very slightly cloudy
Odor: none
Other Comments: —

4 ☐ WELL EVACUATION:
Method: Peristaltic pump
Volume Removed: 2.5 gallons
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: —

Groundwater Sampling Record

Monitoring Well No. LF6-MPK (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

- [] Bailer made of: _____
☒ Pump, type: Peristaltic
☐ Other, describe: _____

Sample obtained is ☒ GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	320	324	330	341	345	Measured with
Temp (°C)	20.2	20.6	20.6	20.5	20.5	YSI SS
pH	6.20	6.30	6.23	6.19	6.18	Oriel 250A
Cond (µS/cm)	502	516	511	505	504	Hach Meter
DO (mg/L)	0.93	0.62	0.34	0.18	0.18	YSI SS
Redox (mV)	-0.7	-0.6	-0.3	-1.0	-1.0	Oriel 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

1/6 gallon 0.3 gal 1.0 2.0 2.3
10 VOAs
1 Poly

8 []

ON-SITE SAMPLE TREATMENT:

- [] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____



Preservatives added:

- Method HCl Containers: VOAs
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

- ☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6-MPL

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/15 1996 1220 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/KN of Parsons ES

WEATHER: 65 Sunny breezy

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC (still sticking up)

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: not finished

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH isopropanol and distilled water

Items Cleaned (List): Probes

2 ☐

PRODUCT DEPTH — FT. BELOW DATUM

Measured with: —

WATER DEPTH 11.75 FT. BELOW DATUM

Measured with: Solinst w/ indicator

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: cloudy red-brown

Odor: none

Other Comments:

4 ☐

WELL EVACUATION:

Method: peristaltic pump

Volume Removed: 1.5 gallons

Observations: Water (slightly) - very) cloudy

Water level (rose - fell - no change)

Water odors: none

Other comments:

Groundwater Sampling Record Monitoring Well No. LF6-MPL (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	<u>11:47</u>	<u>11:54</u>	<u>12:00</u>	<u>12:03</u>		Measured with
Temp (°C)	<u>20.5</u>	<u>20.4</u>	<u>20.5</u>	<u>20.5</u>		<u>YSI SS</u>
pH	<u>6.08</u>	<u>5.84</u>	<u>5.66</u>	<u>5.67</u>		<u>Orion 250A</u>
Cond (µS/cm)	<u>361</u>	<u>268</u>	<u>268</u>	<u>268</u>		<u>Hach Meter</u>
DO (mg/L)	<u>0.63</u>	<u>0.71</u>	<u>0.39</u>	<u>0.28</u>		<u>YSI SS</u>
Redox (mV)	<u>71</u>	<u>41</u>	<u>45</u>	<u>46</u>		<u>Orion 250A</u>
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

gallon 0.5 0.5 0.00 1.25
12 VOAs
1 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

☒

Preservatives added:

Method HCl Containers: VOAs
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP M (number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/13 1996 1630 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: 60° Overcast

DATUM FOR WATER DEPTH MEASUREMENT (Describe): Ground surface

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS) IS NOT) APPARENT

STEEL CASING CONDITION IS: Not done

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH Isopropanol + distilled water
Items Cleaned (List): probes

2 ☐

PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 12.5 FT. BELOW DATUM
Measured with: Solinst water level indicator

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: cloudy brown

Odor: none

Other Comments: —

4 ☐

WELL EVACUATION:

Method: Peristaltic

Volume Removed: 1.3 gallons

Observations: Water (slightly) - very) cloudy

Water level (rose - fell - no change)

Water odors: none

Other comments: —

Groundwater Sampling Record Monitoring Well No. MPM (LFC) (Cont'd)

5 [] SAMPLE EXTRACTION METHOD:

- [] Bailer made of: _____
☒ Pump, type: peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

now better DO readings

Time	<u>2155</u>	<u>1600</u>	<u>1605</u>	<u>1615</u>	<u>1625</u>	Measured with
Temp (°C)	<u>18.9</u>	<u>18.7</u>	<u>18.7</u>	<u>19.1</u>	<u>18.7</u>	<u>YSI 55</u>
pH	<u>5.50</u>	<u>5.53</u>	<u>5.58</u>	<u>5.48</u>	<u>5.43</u>	<u>Orion 250A</u>
Cond (µS/cm)	<u>68</u>	<u>62</u>	<u>62</u>	<u>61</u>	<u>62</u>	<u>Hach Meter</u>
DO (mg/L)	<u>6.38</u>	<u>6.96</u>	<u>5.18</u>	<u>6.20</u>	<u>4.88</u>	<u>YSI 55</u>
Redox (mV)	<u>692</u>	<u>375</u>	<u>81.5</u>	<u>92.0</u>	<u>660</u>	<u>Orion 250A</u>
Salinity (‰)	<u>6.9</u>	<u>75.6</u>	<u>55.7</u>	<u>67.1</u>	<u>52.4</u>	<u>YSI 55</u>
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

10 VOA's
2 Poly's

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

☒ Preservatives added:

Method HCl Containers: VOA's
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

- ☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

needed to surge at beginning
to get flow. Low flow

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6-MPN (number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;
DATE AND TIME OF SAMPLING: 11/17/96 1996 7:15 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: 60° Cloudy

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

☐ LOCKED: ☒ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: good

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐ EQUIPMENT CLEANED BEFORE USE WITH isopropanol + distilled water
Items Cleaned (List): Probes

2 ☐ PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH 20.2 FT. BELOW DATUM
Measured with: Solinst water level indicator

3 ☐ WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: cloudy brown

Odor: none

Other Comments: —

4 ☐ WELL EVACUATION:

Method: Peristaltic

Volume Removed: 3/4 - 1 gallon

Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)

Water odors: —

Other comments: —

Groundwater Sampling Record

Monitoring Well No. LF6-MPN (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	701	706	708	710	712	Measured with
Temp (°C)	17.3	18.0	18.2	18.2	18.3	YSI 55
pH	6.72	6.75	6.75	6.75	6.77	Orion 250A
Cond (µS/cm)	585	599	599	599	599	Hach Meter
DO (mg/L)	1.18	1.02	0.54	0.39	0.32	YSI 55
Redox (mV)	-54	-55	-55	-54	-55	Orion 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

gallons 1/4 1/2 3/4 5/8 3/4
 SAMPLE CONTAINERS (material, number, size): _____
10 JVAS
1 poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:
 Method HCl Containers: JVAS
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6
Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MPO (LF6)
(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;
DATE AND TIME OF SAMPLING: 11/14 1996 730 a.m./p.m.
SAMPLE COLLECTED BY: JHBD CS RN of Parsons ES
WEATHER: 50° Overcast
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Ground surface

MONITORING WELL CONDITION:

☐ LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: not complete
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS IS NOT) APPARENT
☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

- 1 ☐ EQUIPMENT CLEANED BEFORE USE WITH iso propanol + distilled water
Items Cleaned (List): Probes
- 2 ☐ PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —
- WATER DEPTH 4.5' FT. BELOW DATUM
Measured with: Solinst
- 3 ☐ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: slightly cloudy gray brown
Odor: none
Other Comments:
- 4 ☐ WELL EVACUATION:
Method: Peristaltic pump
Volume Removed:
Observations: Water (slightly) - very cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. MPO/LF6 (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is ☒ GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	712	716	720	722	725	Measured with
Temp (°C)	17.8	18.5	18.8	18.8	18.8	YSI 55
pH	4.77	4.75	4.79	4.79	4.80	Orion 250A
Cond (µS/cm)	642	629	630	631	634	Hach meter
DO (mg/L)	0.85	0.46	0.40	0.39	0.26	YSI 55
Redox (mV)	100.0	86.6	84.1	84.9	86.7	Orion 250A
Salinity (‰)	6.2	4.6	4.4	4.0	2.7	YSI 55
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

500 mL 1 gallon 1.25 gal 1.5 gallon 2.0 gallon
10 VOAs
2 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:
 Method HCl Containers: VOAs
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL

LF6MPP

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/14/96, 1996 0920 (a.m./p.m.)

SAMPLE COLLECTED BY: JH/BD/CS/RN of Parsons ES

WEATHER: OVERCAST 50°F

DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:

☐ LOCKED:

☐ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS:

INNER PVC CASING CONDITION IS:

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

WELL NOT COMPLETED

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH

Items Cleaned (List):

2 ☐

PRODUCT DEPTH

FT. BELOW DATUM

Measured with:

WATER DEPTH

5.3'

FT. BELOW DATUM

Measured with:

SOLINST

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance:

Odor:

Other Comments:

4 ☐

WELL EVACUATION:

Method:

Peristaltic

Volume Removed:

Observations:

Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors:

Other comments:

Groundwater Sampling Record

Monitoring Well No. LEMP (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

- [] Bailer made of: _____
 [] Pump, type: _____
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Time	0910	0914	0918			Measured with
Temp (°C)	18.6	18.7	18.8			
pH	4.89	4.79	4.73			
Cond (µS/cm)	212	211	208			
DO (mg/L)	0.34	0.33	0.27			
Redox (mV)	59.4	62.1	67.3			
Salinity						
Nitrate						
Sulfate						
Ferrous Iron	0.2	0.4	0.8			

gallons

7 []

SAMPLE CONTAINERS (material, number, size):

10 40ml glass
 2 125 plastic
 1 145 AMBER glass

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:

Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

- [] Container Sides Labeled
 [] Container Lids Taped
 [] Containers Placed in Ice Chest

10 []

OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - LF6

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LF6-MPQ

(number)

REASON FOR SAMPLING: ☒ Regular Sampling; ☐ Special Sampling;

DATE AND TIME OF SAMPLING: 11/14/1996 1645 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: 65° Clear

DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

☐ LOCKED:

☒ UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: Not complete

INNER PVC CASING CONDITION IS: good

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

☐ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

☐ MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☐

EQUIPMENT CLEANED BEFORE USE WITH Isopropanol and distilled water

Items Cleaned (List): Probes

2 ☐

PRODUCT DEPTH — FT. BELOW DATUM

Measured with: —

WATER DEPTH 4.2 (TOC and GS) FT. BELOW DATUM

Measured with: Sollast

3 ☐

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: Clear

Odor: none

Other Comments:

4 ☐

WELL EVACUATION:

Method: Peristaltic pump

Volume Removed:

Observations: Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors:

Other comments:

11 L = 3 gal
1 L = $\frac{3}{11}$ gallon

1 L = 0.27 gallon

$$\begin{array}{r} 272 \\ 11 \overline{) 30} \\ \underline{22} \\ 80 \\ \underline{77} \\ 30 \end{array}$$

Groundwater Sampling Record

Monitoring Well No. LF6-MPQ (Cont'd)

5 []

SAMPLE EXTRACTION METHOD:

[] Bailer made of: _____
☒ Pump, type: Peristaltic
 [] Other, describe: _____

Sample obtained is [X] GRAB; [] COMPOSITE SAMPLE

6 []

ON-SITE MEASUREMENTS:

Turned Pump off to allow for recharge (1612-)

Time	1545	1558	1606	1612	1640	Measured with
Temp (°C)	18.0	18.1	18.0	18.0	17.5	YSI 55
pH	6.01	6.17	5.79	6.00	6.04	Orion 250A
Cond (µS/cm)	758	641	636	581	410	Hach Meter
DO (mg/L)	4.28	4.33	4.73	4.31	4.78	YSI 55
Redox (mV)	105	133	137	151	152.9	Orion 250A
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 []

SAMPLE CONTAINERS (material, number, size):

0.1g 0.25g 0.5g 0.75g 1.00g
10 VOAs
2 Poly

8 []

ON-SITE SAMPLE TREATMENT:

[] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:
 Method HCl Containers: VOAs
 Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

9 []

CONTAINER HANDLING:

☒ Container Sides Labeled
☒ Container Lids Taped
☒ Containers Placed in Ice Chest

10 []

OTHER COMMENTS: Sample aerated
- pump is on as low as possible

GROUNDWATER SAMPLING RECORD

Sampling Location Columbus AFB - ST24

Sampling Dates 11/04/96-11/24/96

GROUND WATER SAMPLING RECORD - MONITORING WELL LFOG - MPR (number)

REASON FOR SAMPLING: [X] Regular Sampling; [X] Special Sampling; RWA

DATE AND TIME OF SAMPLING: 11/17/96, 1996 1300 a.m./p.m.

SAMPLE COLLECTED BY: JH/BL/CS/RN of Parsons ES

WEATHER: BmH Cloudy, Breezy, 60°F

DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top PVC - Marked

MONITORING WELL CONDITION:

[] LOCKED:

[X] UNLOCKED

WELL NUMBER (S) IS NOT APPARENT

STEEL CASING CONDITION IS: OK

INNER PVC CASING CONDITION IS: OK

WATER DEPTH MEASUREMENT DATUM (S) IS NOT APPARENT

[] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

[] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Isopropyl / DI Water
Items Cleaned (List): Leader Level Indicator
Probes & Flow Through Cell

2 [X] PRODUCT DEPTH N/A FT. BELOW DATUM
Measured with:

WATER DEPTH 4.42' Top PVC / TD = 14.7' Top PVC FT. BELOW DATUM
Measured with: Salinist

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy Brown
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed:
Observations: Water (slightly) - very cloudy
Water level (rose - fell - no change)
Water odors: None
Other comments:

Groundwater Sampling Record

Monitoring Well No. LFOG-MPR (Cont'd)

5 ☒

SAMPLE EXTRACTION METHOD:

☐ Bailer made of: _____
☒ Pump, type: Peristaltic Pump
☐ Other, describe: _____

Sample obtained is ☒ GRAB; ☐ COMPOSITE SAMPLE

6 ☒

ON-SITE MEASUREMENTS:

	<u>VOL. (gal.)</u> <u>2.0</u> <u>2.5</u> <u>3.0</u>					
Time	<u>1240</u>	<u>1245</u>	<u>1250</u>			Measured with
Temp (°C)	<u>19.2</u>	<u>19.2</u>	<u>19.2</u>			
pH	<u>5.01</u>	<u>4.94</u>	<u>4.93</u>			
Cond (µS/cm)	<u>700</u>	<u>750</u>	<u>750</u>			
DO (mg/L)	<u>0.16</u>	<u>0.17</u>	<u>0.18</u>			
Redox (mV)	<u>64.3</u>	<u>63.6</u>	<u>55.9</u>			
Salinity						
Nitrate						
Sulfate						
Ferrous Iron						

7 ☒

SAMPLE CONTAINERS (material, number, size): 10 VOA - All HCL
125 ml Plastic
Glass Mason Jars

8 ☒

ON-SITE SAMPLE TREATMENT:

☐ Filtration: NA Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

☐ Preservatives added: All VOAs HCL
 Method STEX Containers: _____
 Method TU-14-G Containers: _____
 Method Methum Containers: _____
 Method VOCS Containers: _____

9 ☒

CONTAINER HANDLING:

☒ Container Sides Labeled
☐ Container Lids Taped
☒ Containers Placed in Ice Chest

10 ☐

OTHER COMMENTS: _____

APPENDIX A-4
SLUG TEST RESULTS

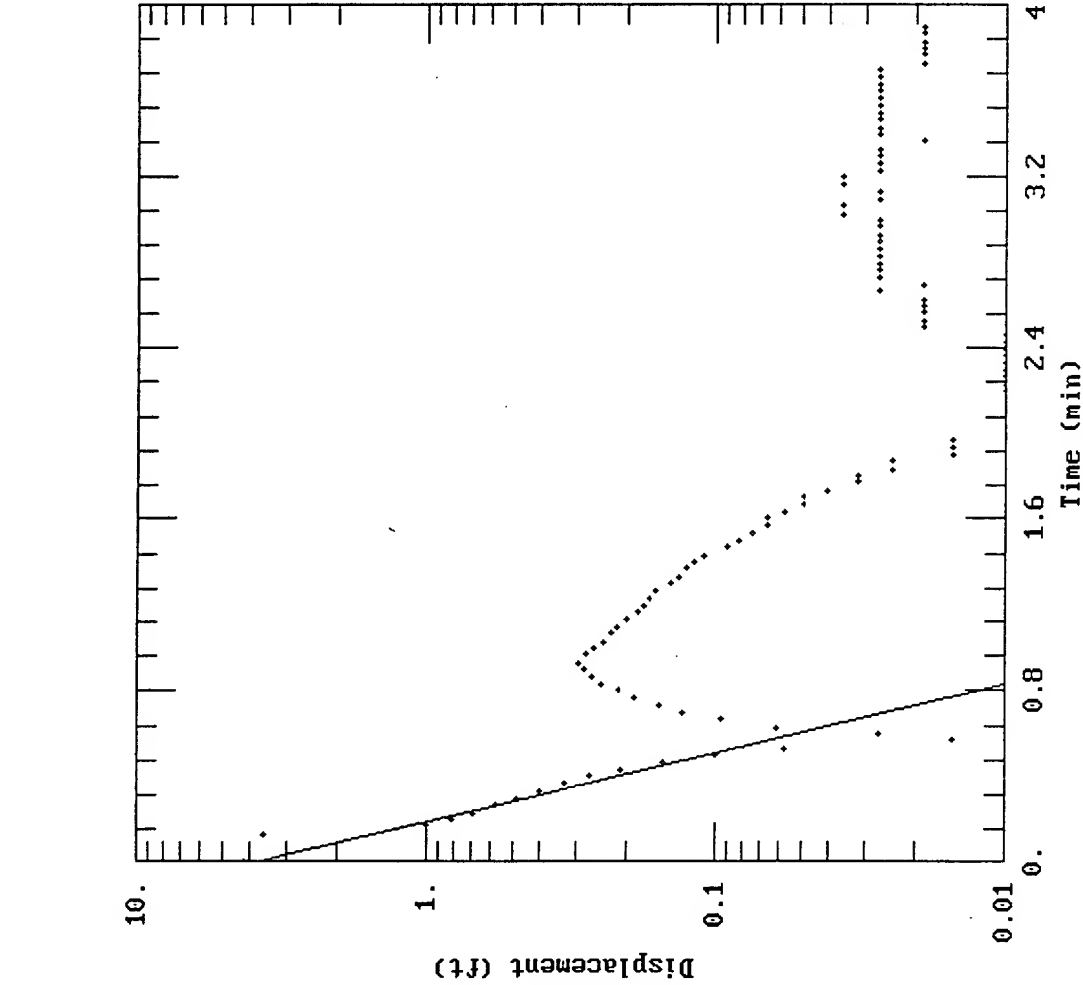
CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 82 Rising Head Test 1



DATA SET:
WB206R1.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0 = 4.2 ft
rc = 0.083 ft
rw = 0.66 ft
L = 10. ft
b = 40. ft
H = 10. ft

PARAMETER ESTIMATES:
K = 0.09108 ft/min
y0 = 3.695 ft

CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 82 Falling Head Test 1

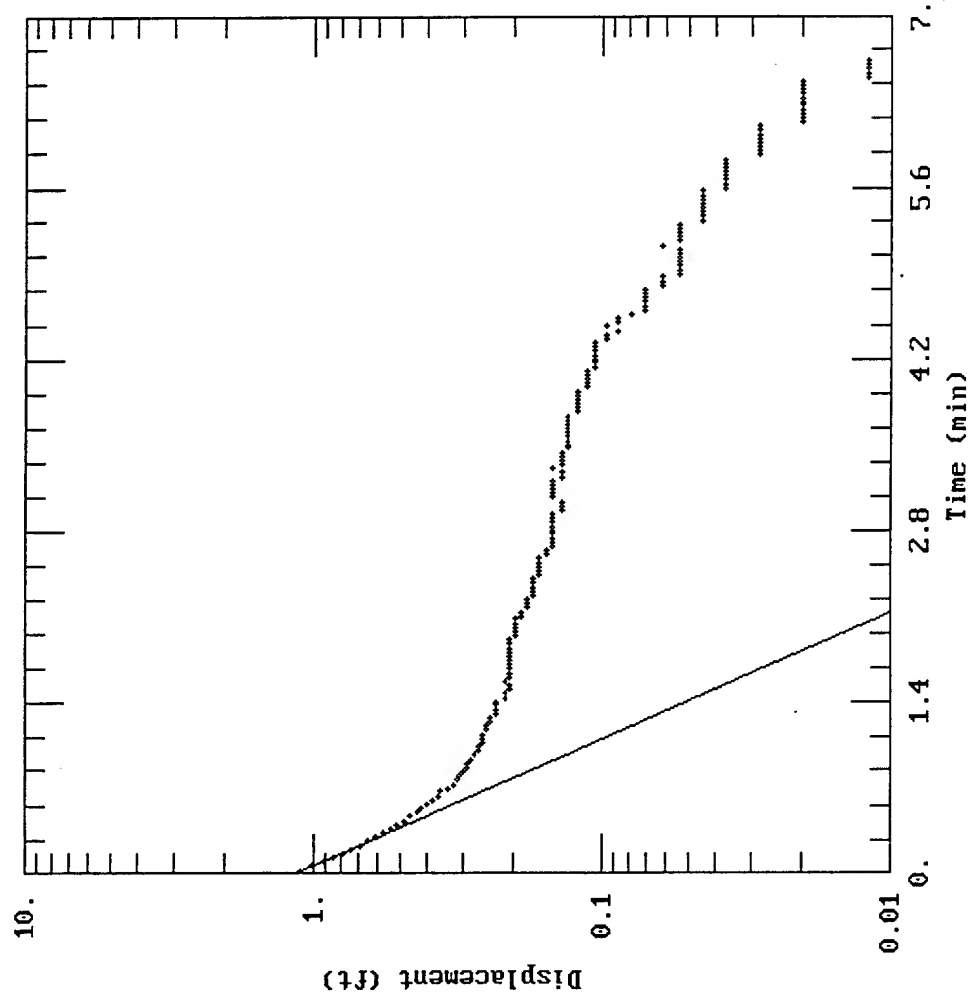
DATA SET:
WB20611.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0 = 1.1 ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
L = 10. ft
b = 40. ft
H = 10. ft

PARAMETER ESTIMATES:
K = 0.02846 ft/min
 $y_0 = 1.145$ ft



CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 82 Rising Head Test 2

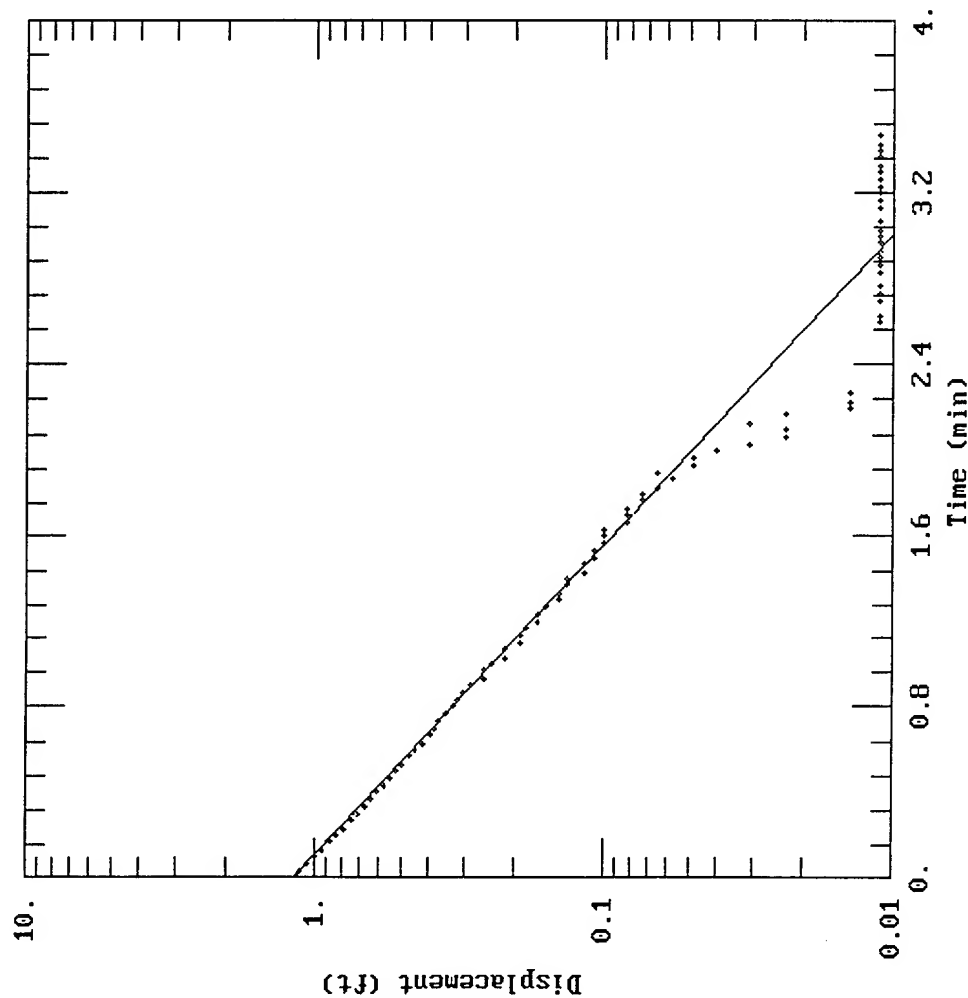
DATA SET:
W8206R2.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 1.133$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.02021$ ft/min
 $y_0 = 1.167$ ft



CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 82 Falling Head Test 2

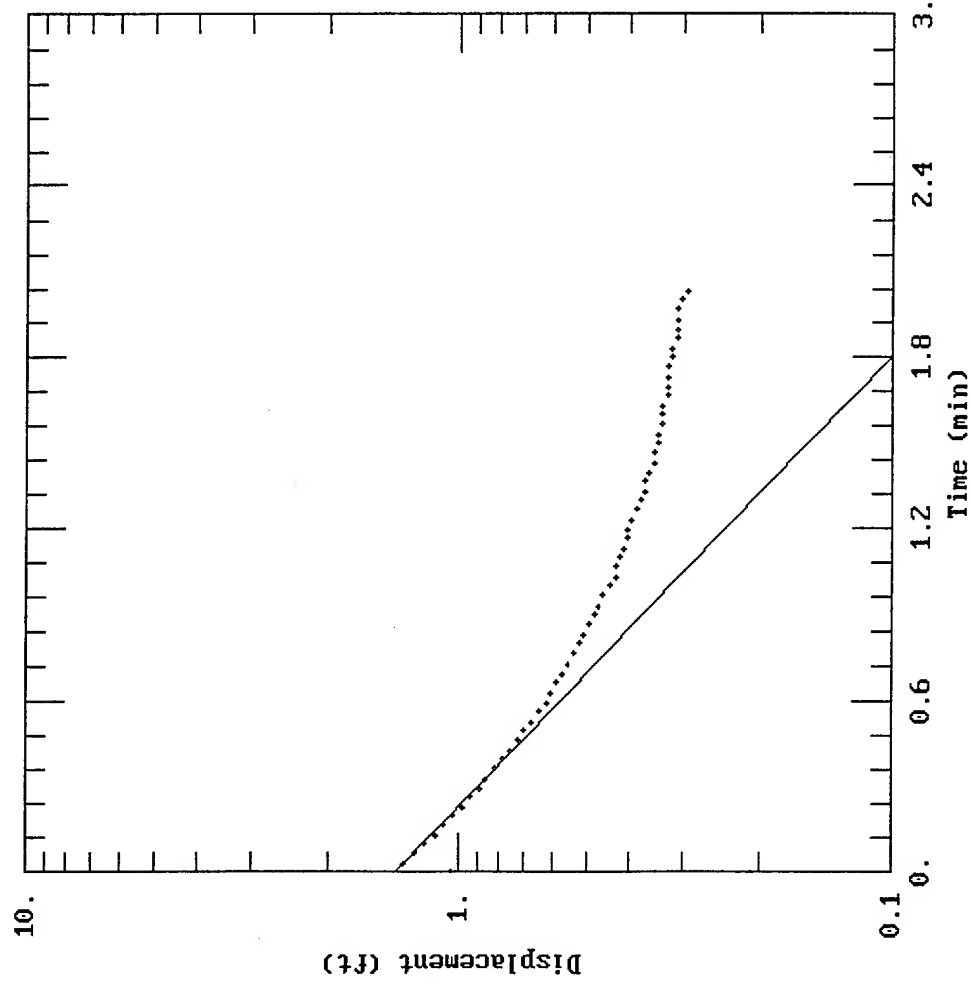
DATA SET:
WB20612.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 1.04$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.01866$ ft/min
 $y_0 = 1.39$ ft

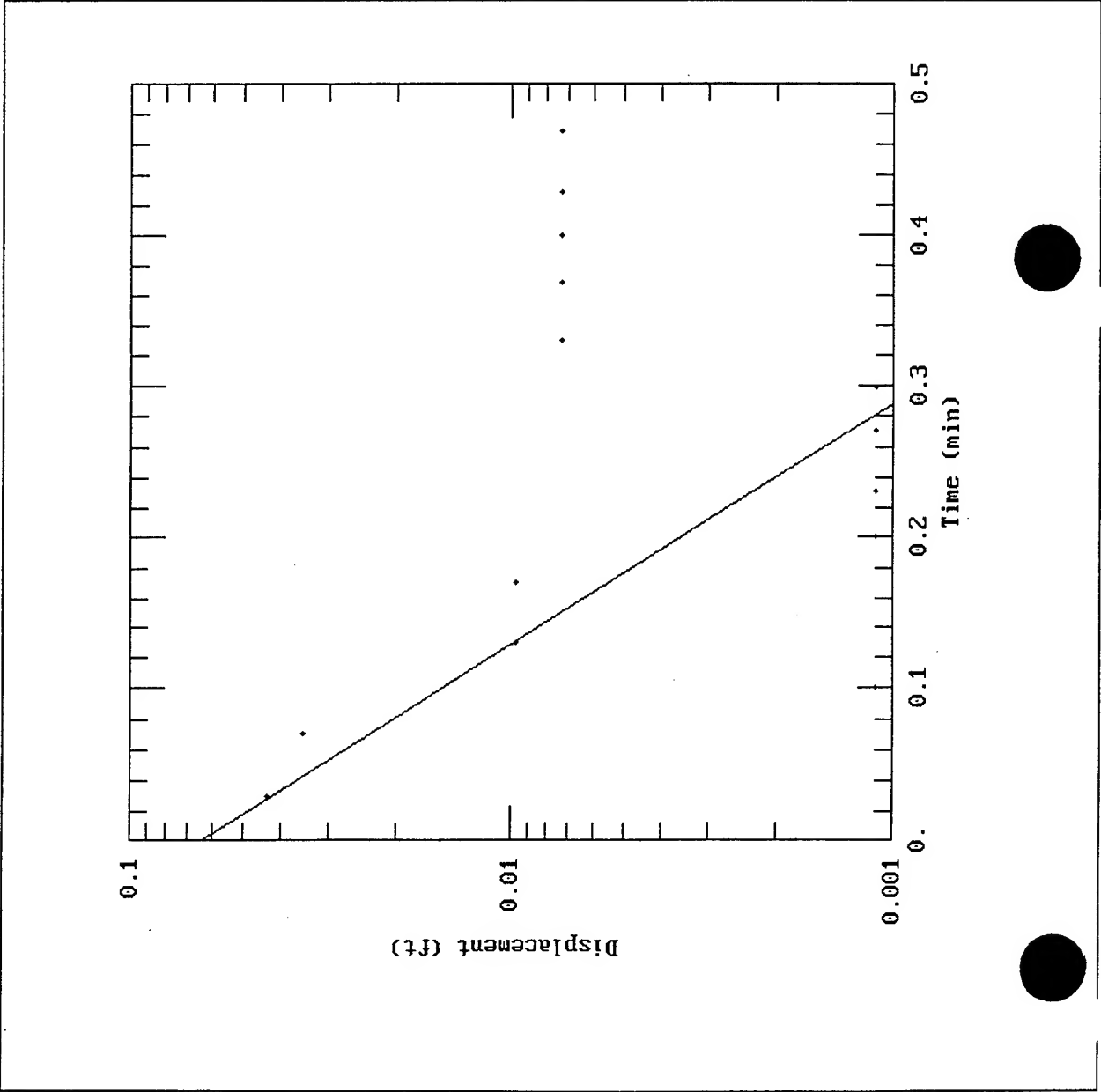


CLIENT: AFCEE	COMPANY: PARSONS E.S.
LOCATION: Columbus AFB, Mississippi	PROJECT: 729691.32050

Well 81 Rising Head Test 1

DATA SET: W8106R1.AQT 03/07/97
AQUIFER MODEL: Unconfined
SOLUTION METHOD: Bouwer-Rice
TEST DATA: H0= 0.439 ft rc= 0.083 ft rw= 0.66 ft L = 10. ft b = 40. ft H = 10. ft

PARAMETER ESTIMATES: K = 0.1841 ft/min y0 = 0.06415 ft
--



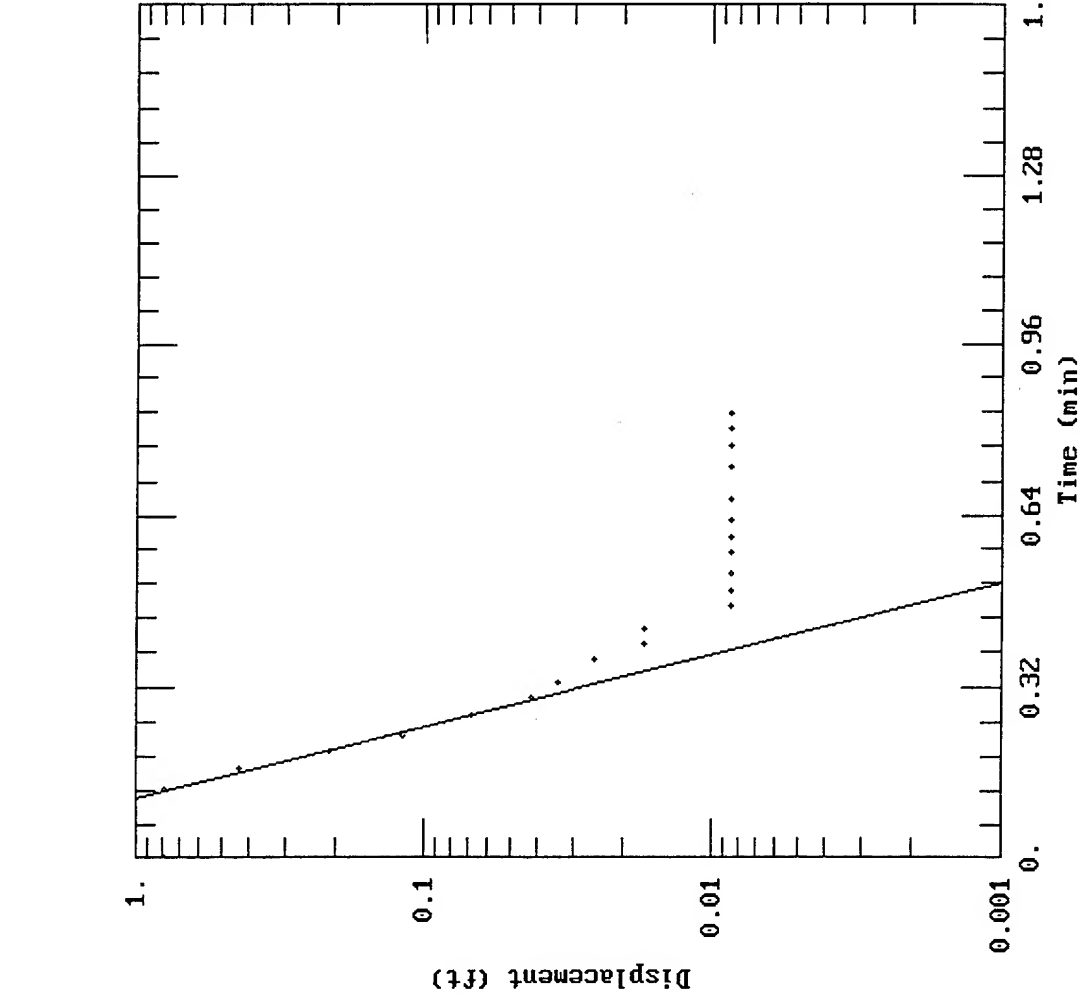
CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 81 Rising Head Test 2



DATA SET:
W8106R2.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 0.7943$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.2195$ ft/min
 $y_0 = 6.852$ ft

CLIENT: AFCEE

COMPANY: PARSONS E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 81 Falling Head Test 2

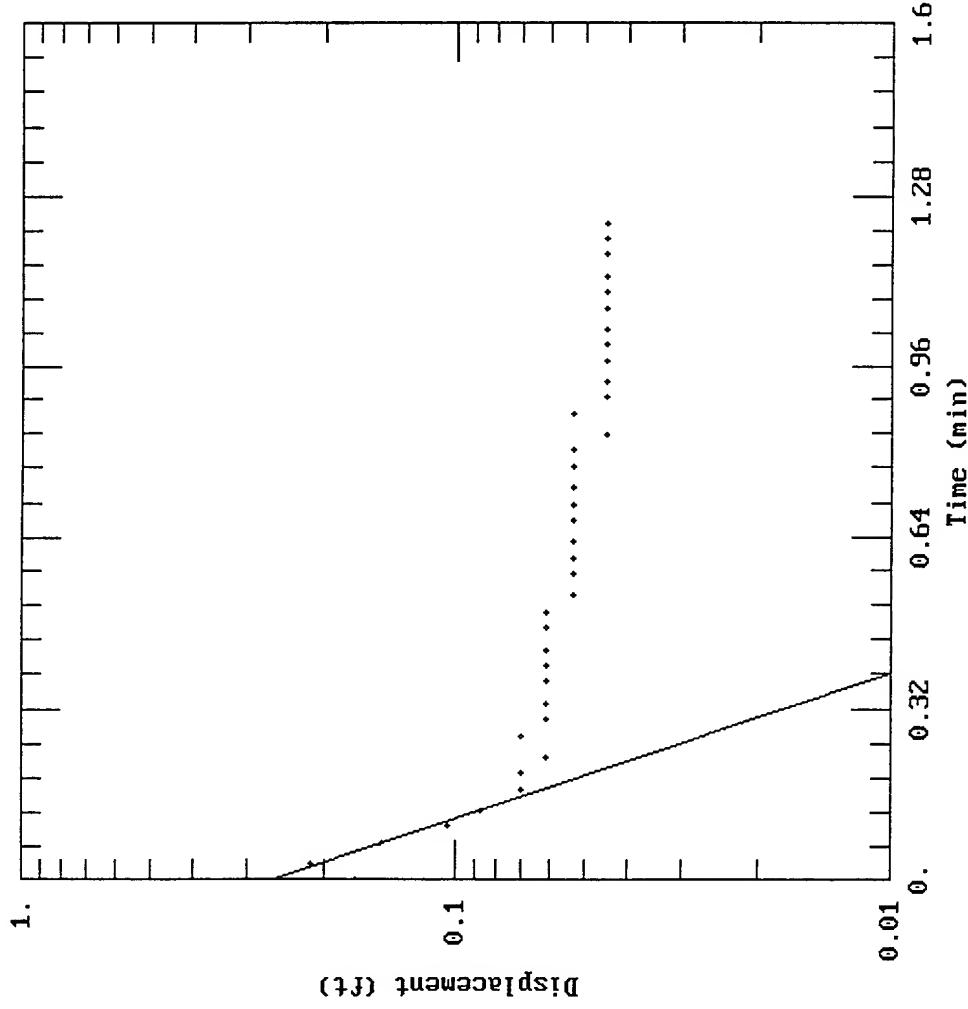
DATA SET:
WB10612.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 0.169$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.1084$ ft/min
 $y_0 = 0.2609$ ft



CLIENT: AFCEE	COMPANY: PARSONS E.S.
LOCATION: Columbus AFB, Mississippi	PROJECT: 729691.32050
Well 81 Falling Head Test 1	
<div> <div>DATA SET: W810611.AQT 03/07/97</div> <div>AQUIFER MODEL: Unconfined</div> <div>SOLUTION METHOD: Bouwer-Rice</div> <div>TEST DATA: H0 = 0.439 ft rc = 0.083 ft rw = 0.66 ft L = 10. ft b = 40. ft H = 10. ft</div> <div>PARAMETER ESTIMATES: K = 0.1472 ft/min y0 = 18.23 ft</div> </div>	

CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 22 Rising Head Test 2

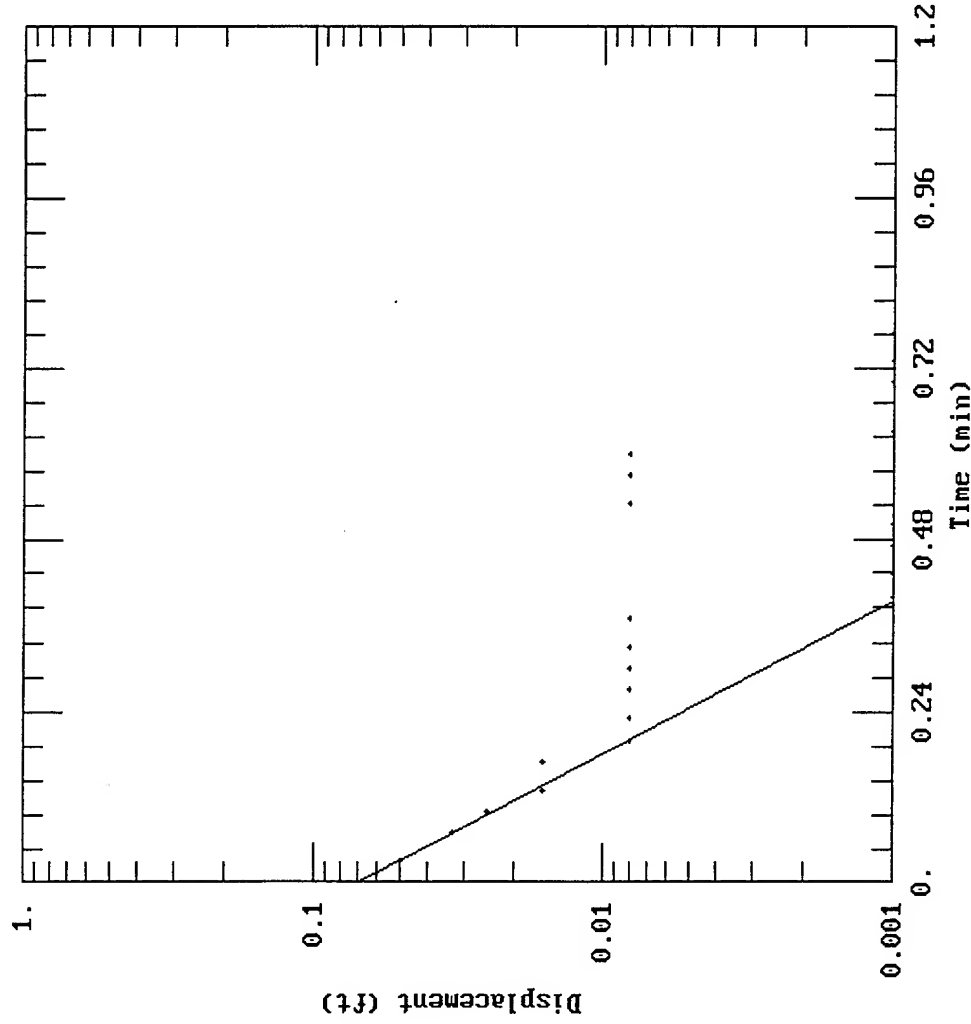
DATA SET:
W2206R2.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 0.05$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.1376$ ft/min
 $y_0 = 0.06879$ ft



CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 22 Falling Head Test 2

DATA SET:
W2206F2.AQT
03/07/97

AQUIFER MODEL:
Unconfined

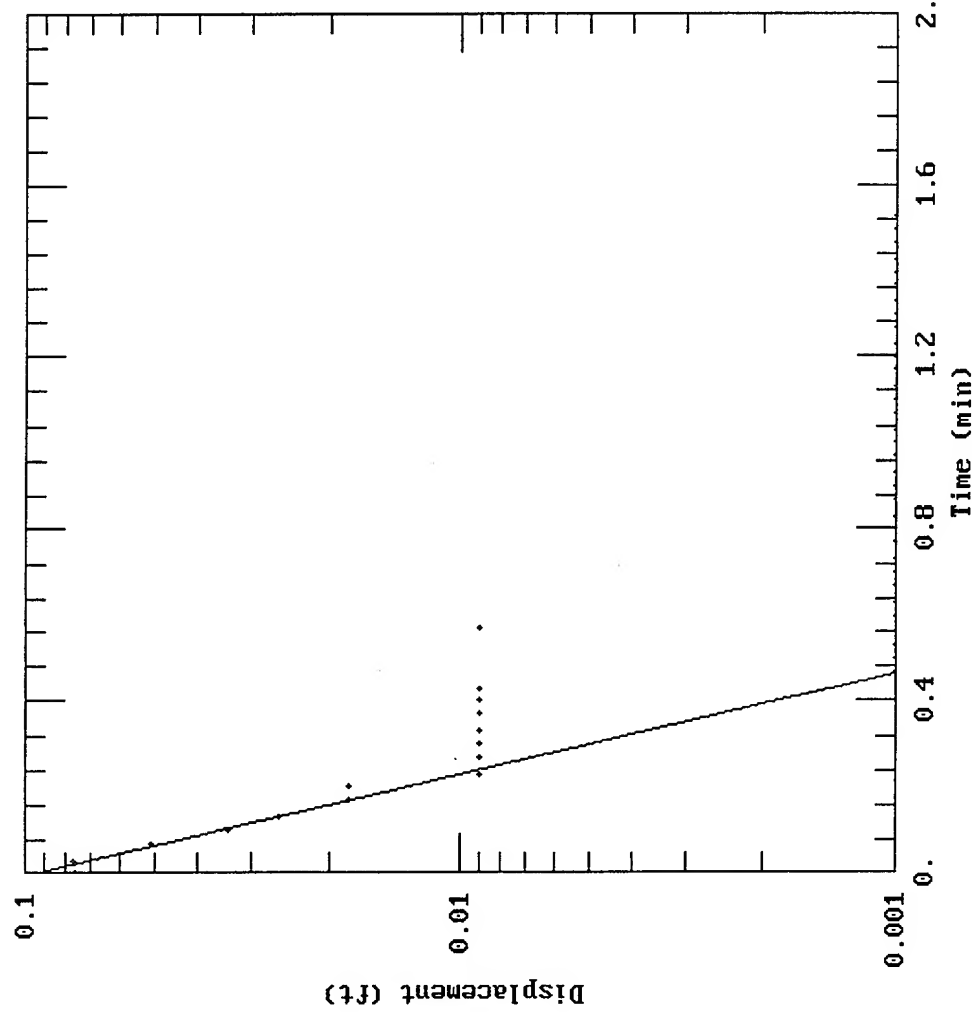
SOLUTION METHOD:
Bouwer-Rice

TEST DATA:

H₀ = 0.076 ft
r_c = 0.083 ft
r_w = 0.66 ft
L = 10. ft
b = 40. ft
H = 10. ft

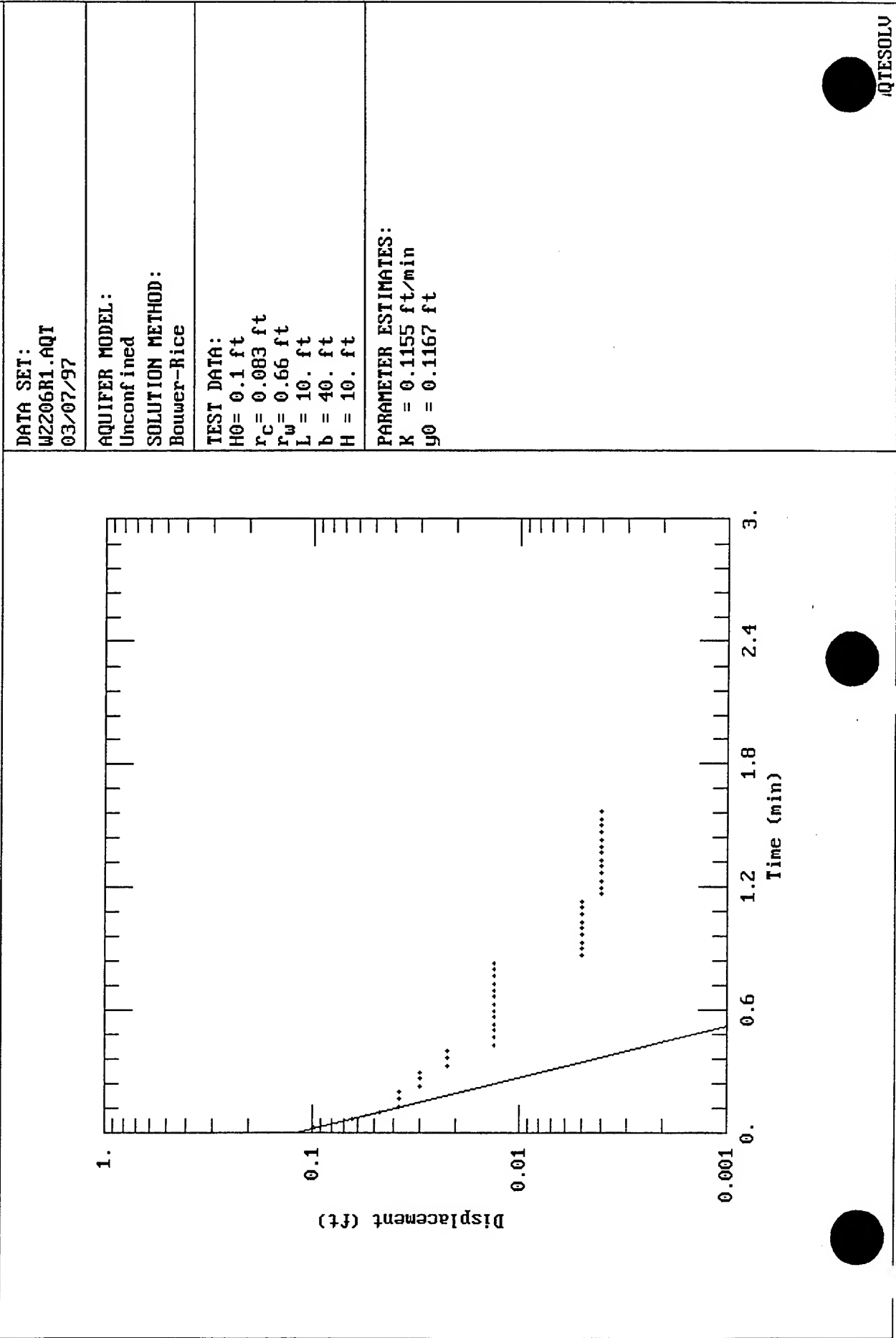
PARAMETER ESTIMATES:

K = 0.1249 ft/min
y₀ = 0.09306 ft



CLIENT: AFCEE	COMPANY: PARSONS E.S.
LOCATION: Columbus AFB, Mississippi	PROJECT: 729691.32050

Well 22 Rising Head Test 1



CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 22 Falling Head Test 1

DATA SET:
W220611.AQT
03/07/97

AQUIFER MODEL:
Unconfined

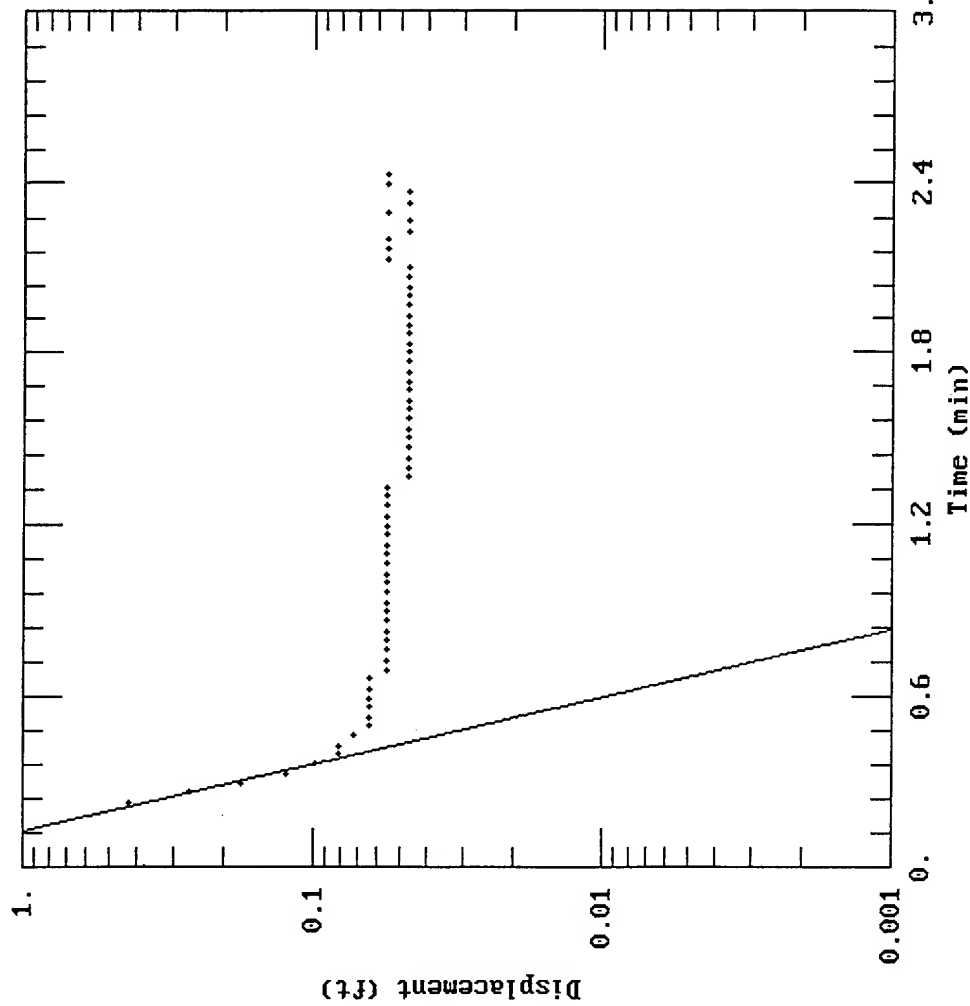
SOLUTION METHOD:
Bouwer-Rice

TEST DATA:

H0 = 0.38 ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
L = 10. ft
b = 40. ft
H = 10. ft

PARAMETER ESTIMATES:

K = 0.1243 ft/min
y0 = 3.505 ft



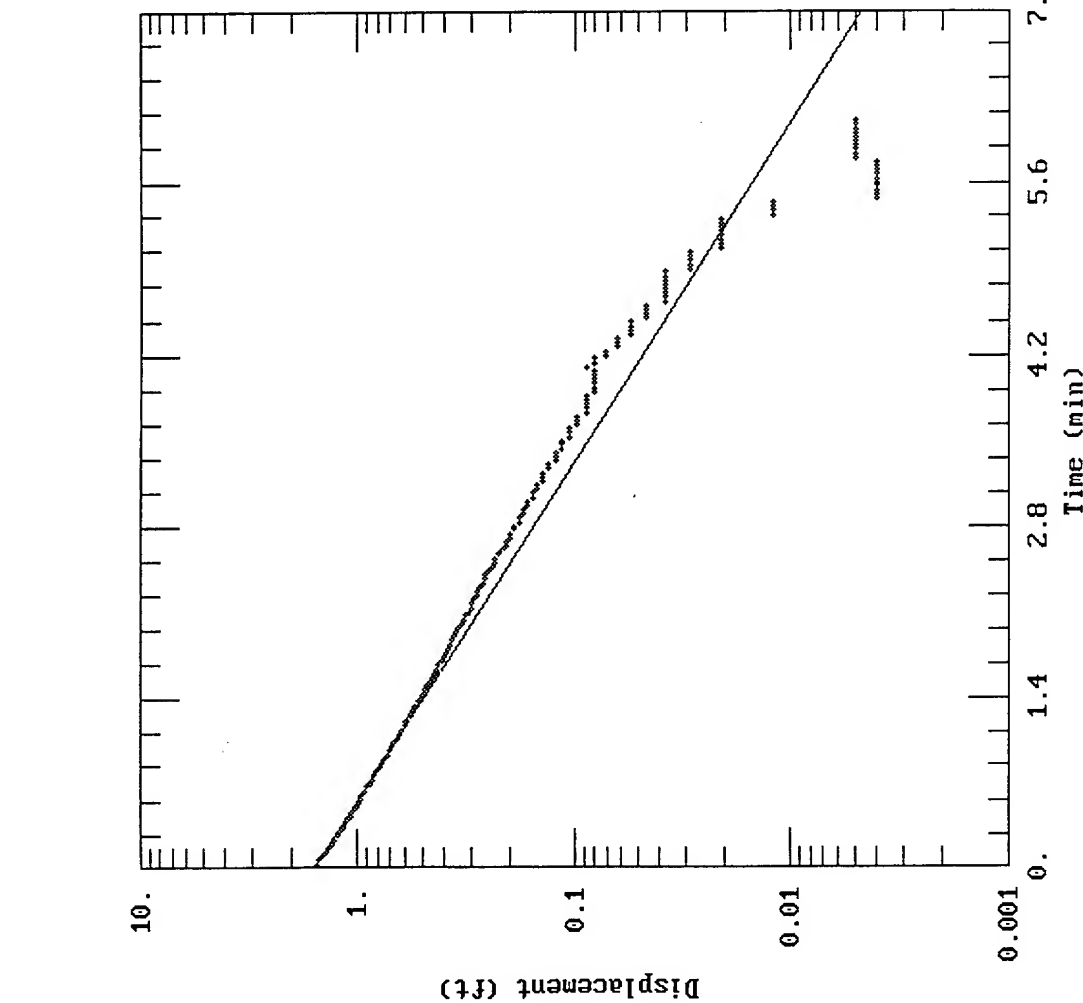
CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 79 Rising Head Test Z



DATA SET:
W7906RZ.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0 = 1.555 ft
rc = 0.083 ft
rw = 0.66 ft
L = 10. ft
b = 40. ft
H = 10. ft

PARAMETER ESTIMATES:
K = 0.01059 ft/min
y0 = 1.562 ft

CLIENT: AFCEE

COMPANY: PARSONS E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 79 Falling Head Test 2

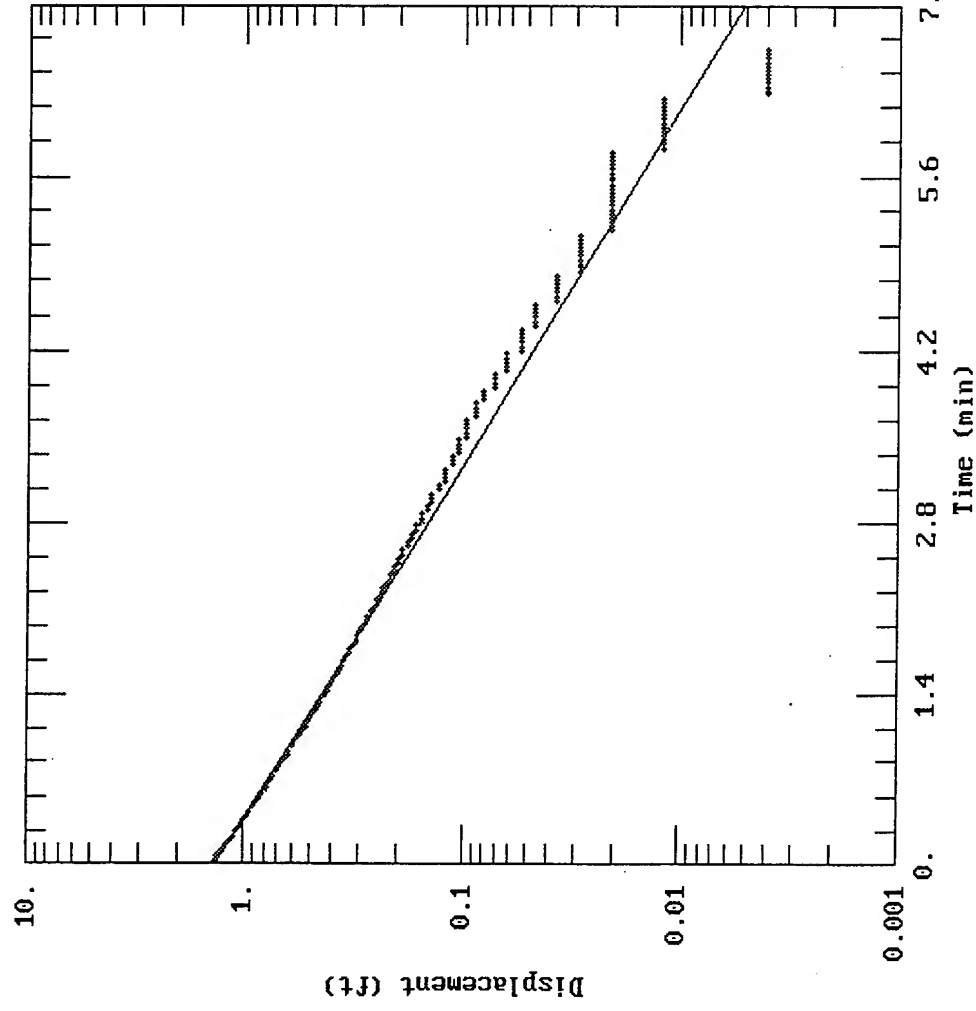
DATA SET:
W790612.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 1.368$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.01017$ ft/min
 $y_0 = 1.343$ ft



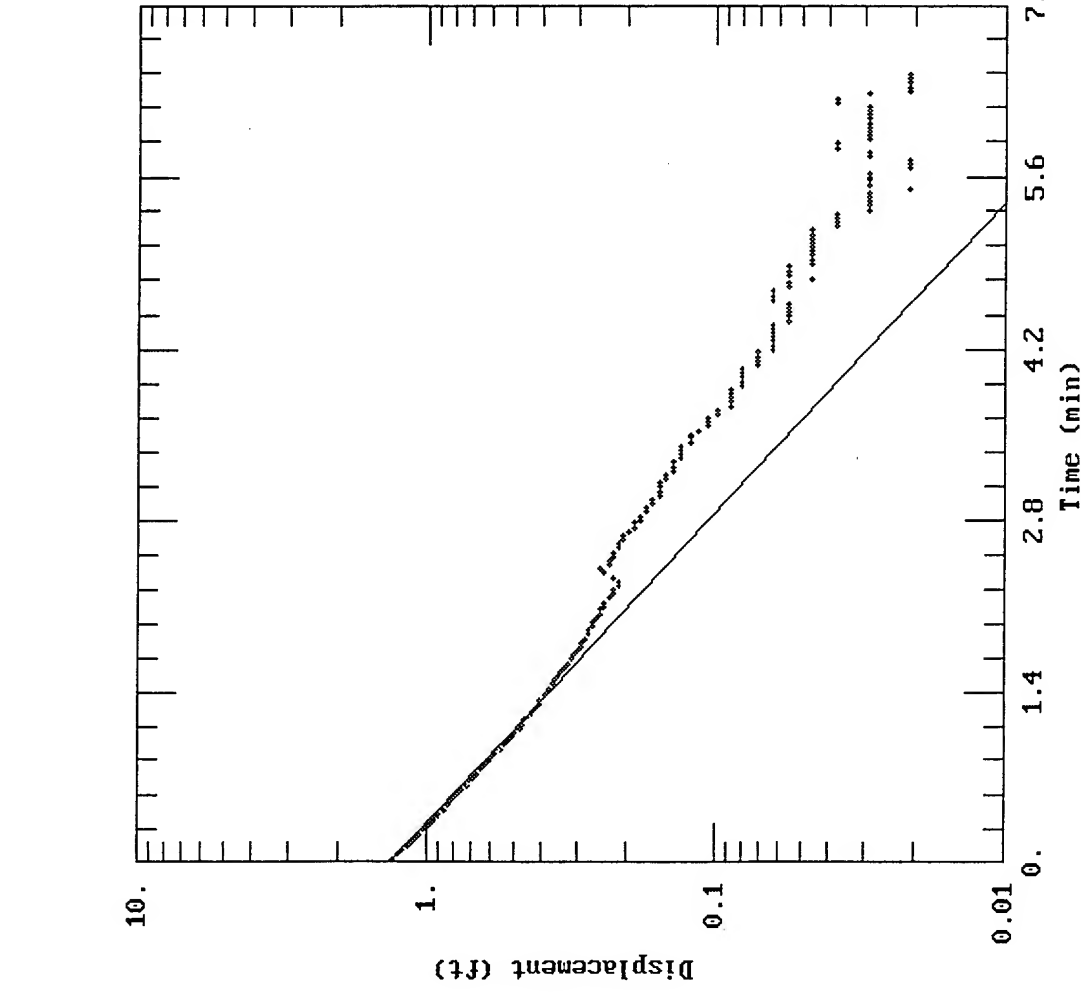
CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 79 Falling Head Test 1



DATA SET:
W790611.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 1.29$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.0116$ ft/min
 $y_0 = 1.332$ ft

CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 79 Rising Head Test 1

DATA SET:
W7906R2.AQT
03/07/97

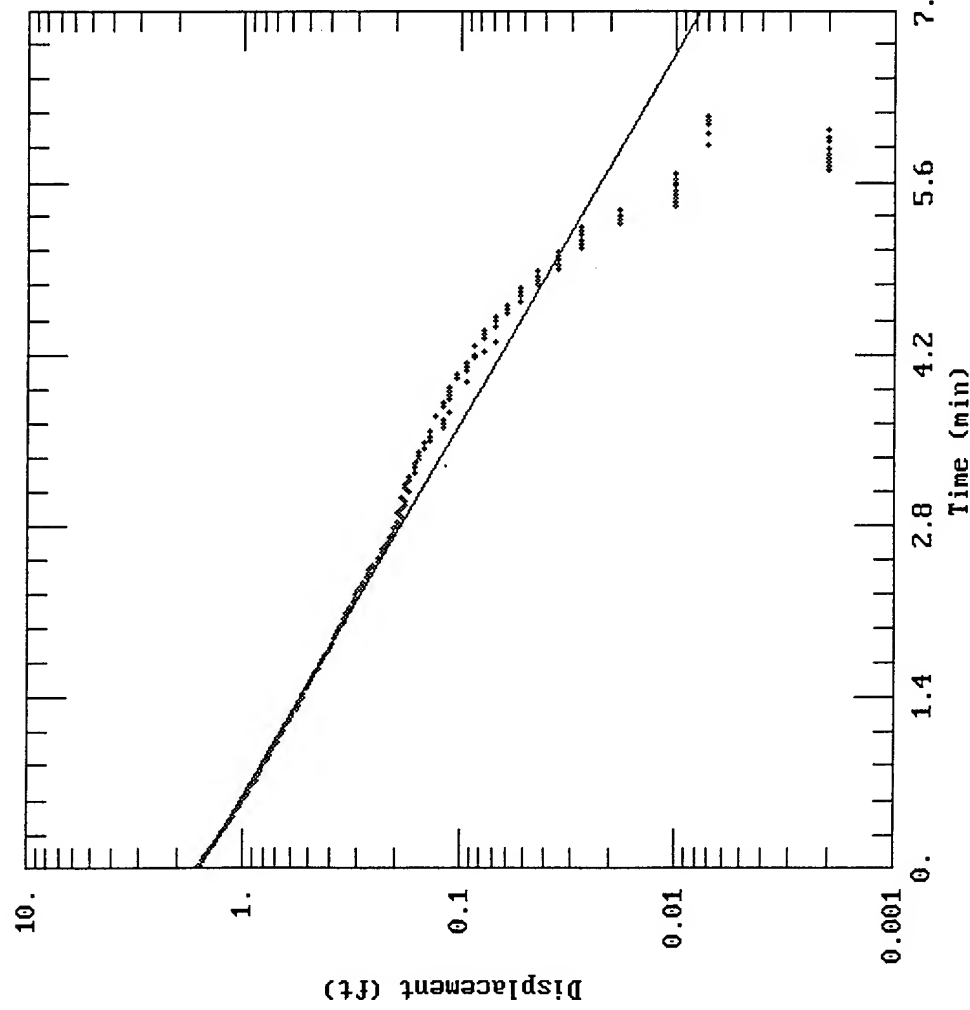
AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:

H₀ = 1.62 ft
r_c = 0.083 ft
r_w = 0.66 ft
L = 10. ft
b = 40. ft
H = 10. ft

PARAMETER ESTIMATES:
K = 0.009694 ft/min
y₀ = 1.562 ft



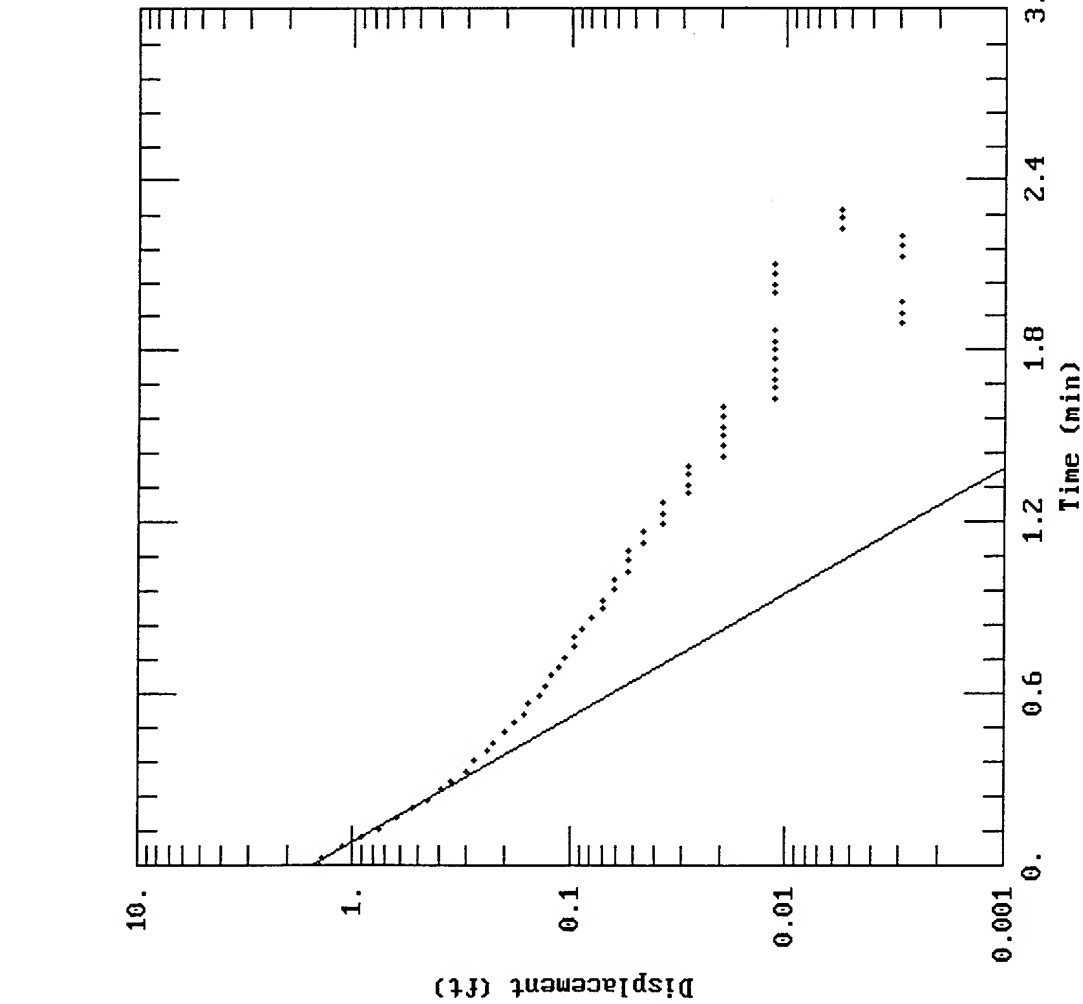
CLIENT: AFCEE

COMPANY: PARSONS E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 18 Rising Head Test 1



DATA SET:
W1806R1.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0 = 1.403 ft
rc = 0.083 ft
rw = 0.66 ft
L = 10. ft
b = 40. ft
H = 10. ft

PARAMETER ESTIMATES:
K = 0.06733 ft/min
y0 = 1.523 ft

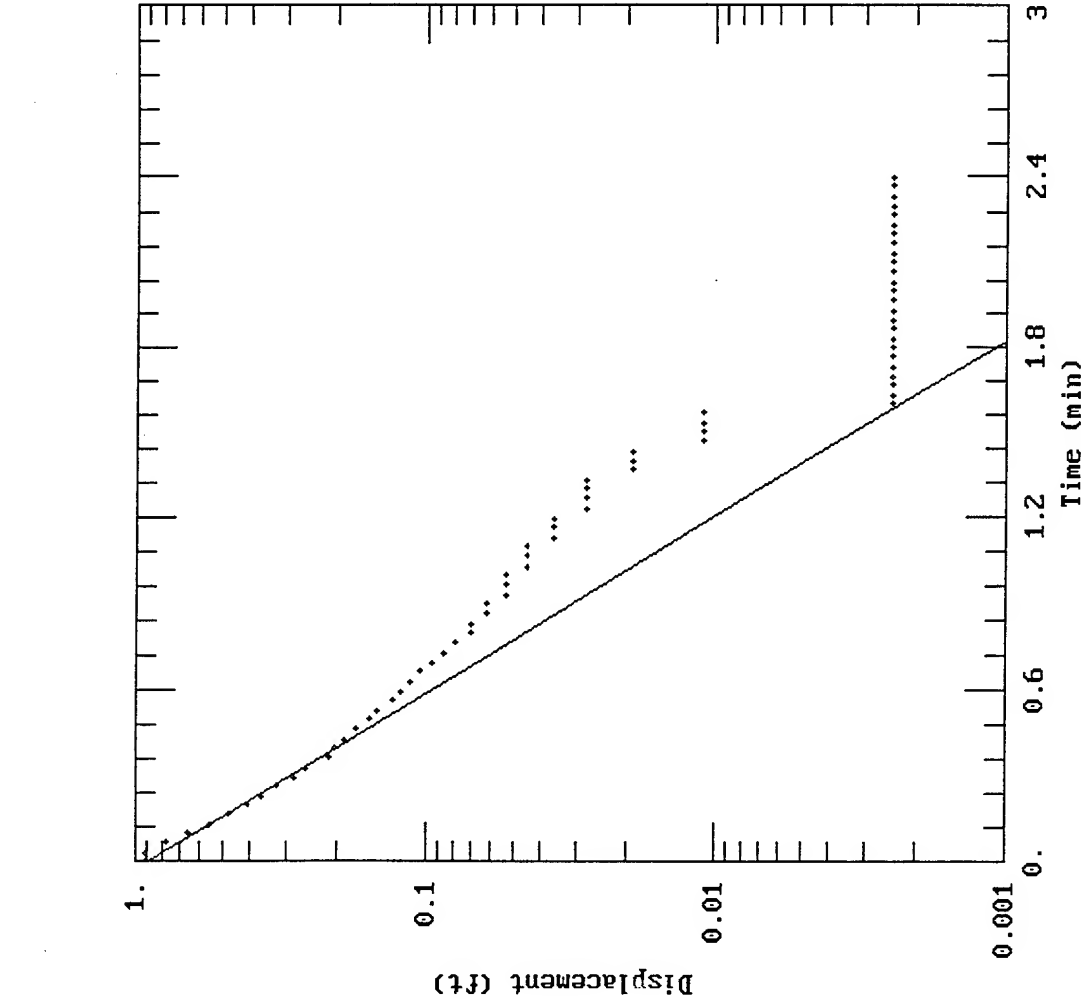
CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 18 Falling Head Test 1



DATA SET:
W180611.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 0.921$ ft
 $r_c = 0.083$ ft
 $r_w = 0.56$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.04757$ ft/min
 $y_0 = 0.8977$ ft

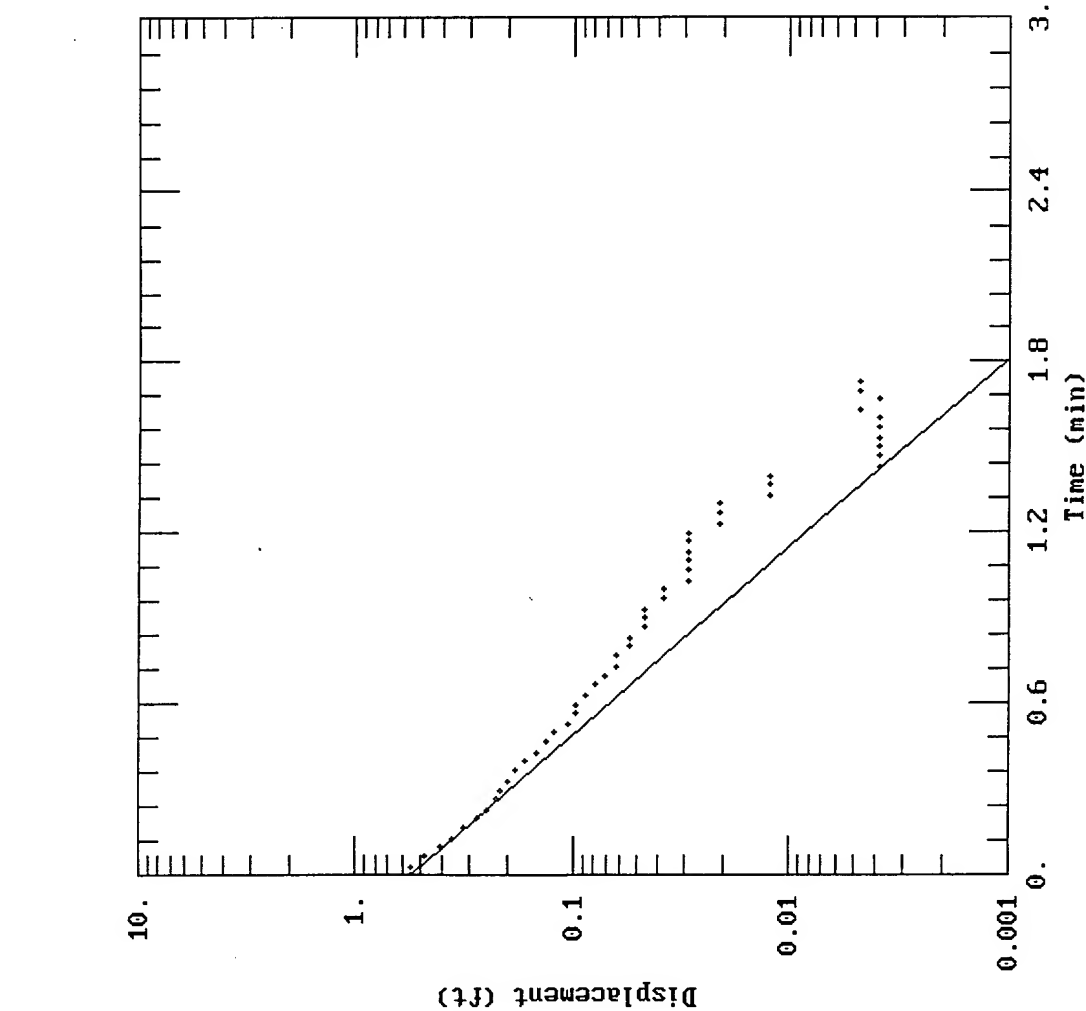
CLIENT: AFCEE

COMPANY: PARSONS E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 18 Rising Head Test 2



DATA SET:
W1806R2.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 0.558$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.04459$ ft/min
 $y_0 = 0.5563$ ft

CLIENT: AFCEE

COMPANY: PARSONS E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 18 Falling Head Test 2

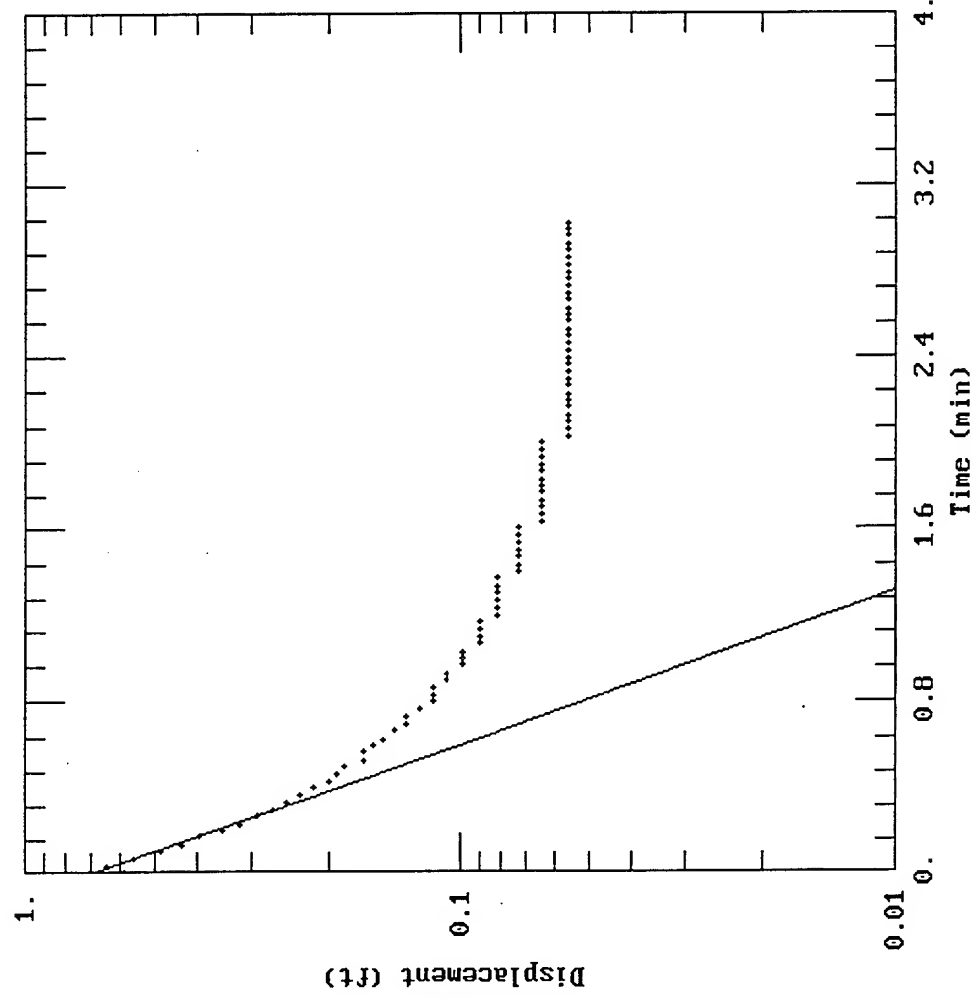
DATA SET:
W180612.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 0.592$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.04132$ ft/min
 $y_0 = 0.6879$ ft



CLIENT: AFCEE

COMPANY: PARSONS E.S.

LOCATION: COLUMBUS AFB, MISSISSIPPI

PROJECT: 729691.32050

Well 19 Rising Head Test 1

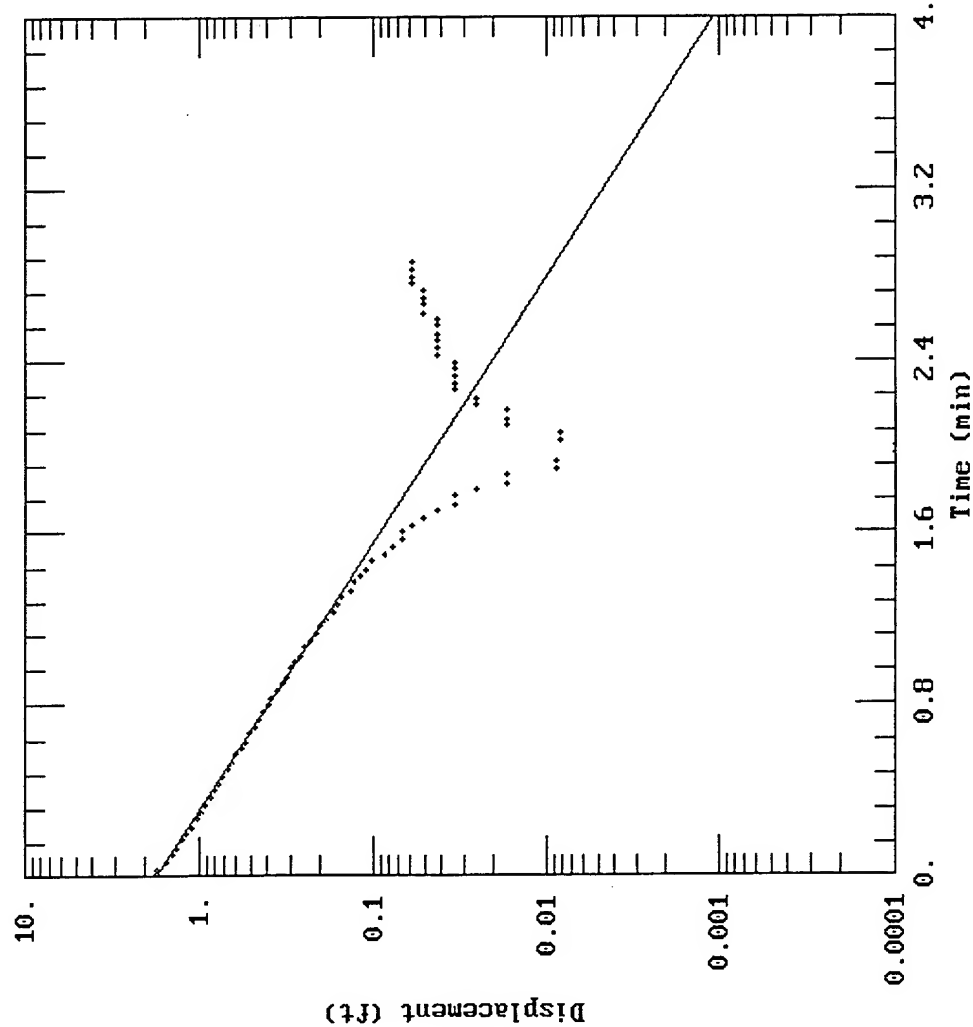
DATA SET:
W1906R1.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0 = 1.774 ft
rc = 0.083 ft
rw = 0.66 ft
L = 10. ft
b = 40. ft
H = 10. ft

PARAMETER ESTIMATES:
K = 0.02357 ft/min
y0 = 1.731 ft



CLIENT: AFCEE	COMPANY: Parsons E.S.
LOCATION: Columbus AFB, Mississippi	PROJECT: 729691.32050
Well 19 Falling Head Test 1	
<div>DATA SET: W190611.AQT 03/07/97</div> <div>AQUIFER MODEL: Unconfined</div> <div>SOLUTION METHOD: Bouwer-Rice</div> <div>TEST DATA: H0= 1.191 ft rc= 0.083 ft rw= 0.66 ft L= 10. ft b= 40. ft H= 10. ft</div> <div>PARAMETER ESTIMATES: K = 0.01799 ft/min y0 = 1.277 ft</div>	

Time (min)	Displacement (ft)
0.0	1.191
0.5	0.5
1.0	0.25
1.5	0.15
2.0	0.1
2.5	0.08
2.8	0.07
3.0	0.06
3.5	0.05
4.0	0.04
4.5	0.03
5.0	0.02
5.5	0.015
6.0	0.01
6.5	0.008
7.0	0.006

QTESOLV

CLIENT: AFCEE

COMPANY: Parsons E.S.

LOCATION: Columbus AFB, Mississippi

PROJECT: 729691.32050

Well 19 Falling Head Test 2

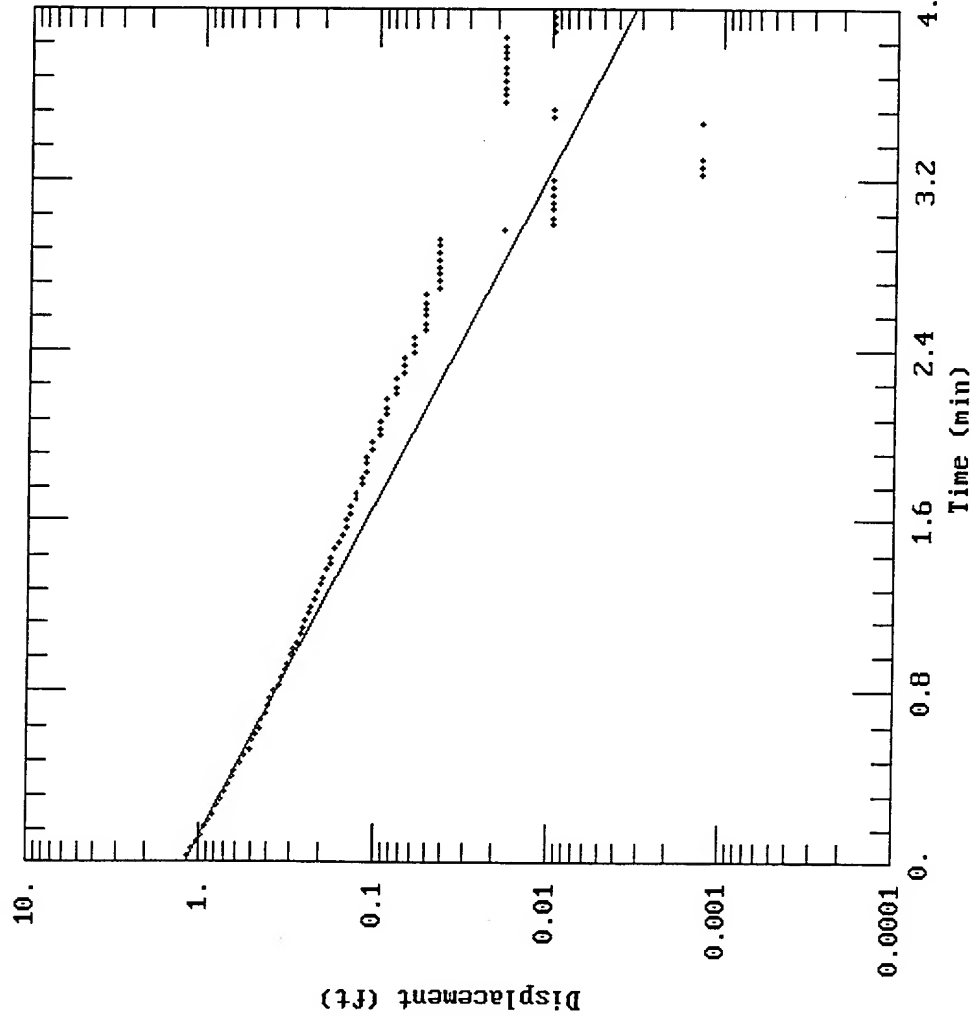
DATA SET:
W190612.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 1.15$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.01891$ ft/min
 $y_0 = 1.186$ ft



CLIENT: AFCEE

COMPANY: PARSONS E.S.

LOCATION: COLUMBUS AFB, MISSISSIPPI

PROJECT: 729691.32050

Well 19 Rising Head Test 2

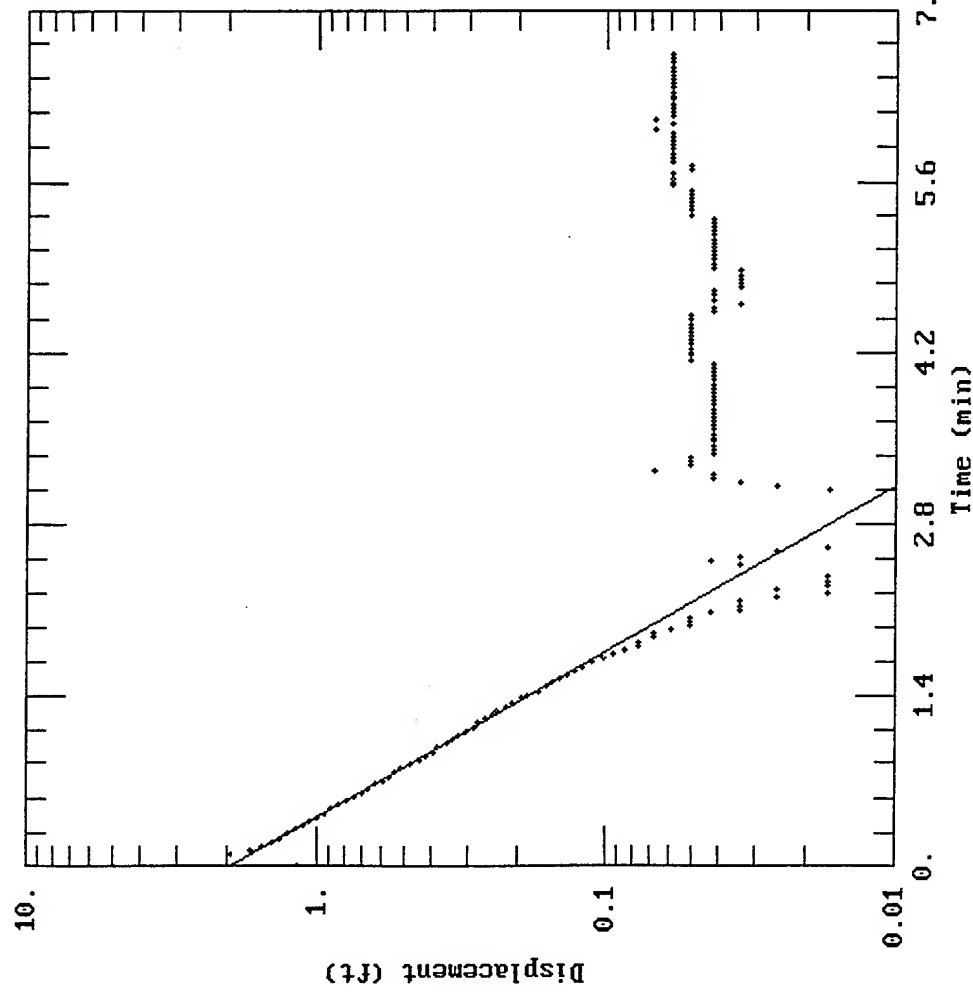
DATA SET:
W1906R2.AQT
03/07/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
 $H_0 = 1.15$ ft
 $r_c = 0.083$ ft
 $r_w = 0.66$ ft
 $L = 10.$ ft
 $b = 40.$ ft
 $H = 10.$ ft

PARAMETER ESTIMATES:
 $K = 0.02164$ ft/min
 $y_0 = 1.944$ ft



APPENDIX B
SOIL AND GROUNDWATER ANALYTICAL RESULTS



CASE NARRATIVE

Evergreen Analytical Laboratory (EAL) Projects: 96-3990, 96-3996, 96-4004, 96-4020, 96-4033, 96-4047, 96-4058, 96-4064 and 96-4081

Parsons Engineering Science, Inc. (PES) Project:

Columbus AFB
729691.32010

Sample Receipt

Soil and groundwater samples were received between November 9 and 19, 1996 from Columbus AFB for analysis under Subcontract 729691.00000. Refer to the check-in portion of the EAL Chain of Custody for specific information regarding the condition of samples upon receipt. Refer to the EAL Work Order Summary for log-in information and cross-reference of EAL and PES sample identifications.

Data Package

All data are reported in one comprehensive package that is segregated based upon EAL project number. Each EAL project represents a group of samples received on a given day. The EAL Work Order Summary lists the samples represented in each EAL project.

A separate invoice for each EAL project number will be generated.

Quality assurance data may overlap from one EAL project to another. All required matrix spike/matrix spike duplicate (MS/MSD) and laboratory control samples (LCS) were analyzed when required and also are included in the data package.

BTEX, Method SW8020/Total Volatile Petroleum Hydrocarbons TVPH, Method SW8015M
All samples were analyzed for BTEX/TVPH within holding time.

Several samples were analyzed at dilutions ranging from a dilution factor of 5 to 200 due to elevated levels of contaminants. The reporting limits have been raised accordingly.

The 1,3,5-trimethylbenzene spike duplicate recovery on sample ST24-MPG was below the EAL acceptance criteria. Reanalysis confirmed matrix effect and non-homogeneous sample.

The 1,2,4-trichlorobenzene surrogate for TVPH analysis could not be separated from the hydrocarbon interference on samples ST24-MPE, ST24-MPD(D) and W3 MS/MSD.

Chlorinated Volatile Organic Compound, VOC's, Method SW8010

All samples were analyzed for chlorinated VOC's within holding time.

Samples LF06-MPF and LF6-MPV were analyzed at a dilution factor of 5 due to elevated levels of contaminants. The reporting limits were raised accordingly. Sample ST24-MPM was analyzed at a dilution factor of 10 to recover the 1-chloro-2-fluoro-benzene surrogate which could not be separated from the hydrocarbon interference at a dilution factor of one.

1,3-dichlorobenzene was indicated on the GC chromatogram for several samples. Mass spectrometer confirmation indicated the compound is 1,4-dichlorobenzene. The GC/MS Quant Reports have been included for your review.

Methane, Method RSKSOP-175M

All samples were analyzed for methane within holding time.

Several samples were analyzed at dilutions ranging from a dilution factor of 5 to 100 due to elevated levels of methane present. The reporting limits were raised accordingly.

Only 2.5 of the required 4 MLs headspace was created in sample W73 due to solids in the sample.

General Chemistry

There are no quality assurance anomalies to report for the following analyses: Anions by Method E300.0, Alkalinity by Method E310.1, Total Organic Carbon in water by Method E415.1 or Total Recoverable Petroleum Hydrocarbons by Method E418.1.

Total Organic Carbon in Soil

Total Organic Carbon (TOC) in soils was analyzed by Huffman Laboratories of Golden Colorado. TOC was determined by analyzing for total carbon (TC) and inorganic (carbonate) carbon (CC), then calculating the difference as TOC. The reports from Huffman are included.

Disk Deliverables

The disk deliverables are included with the hard copy data package. MS/MSD and LCS results are not included on the disk. Please note that blank spaces in the laboratory detection limit and/or practical quantitation limit (PQL) column indicate that there is no detection limit or PQL for that analyte.

Reporting limits have been adjusted to reflect percent moisture in all soil samples or increases due to dilutions.

A hard copy of each spreadsheet from the diskette is included. The name for each spreadsheet is located in the top left corner on the first page of each printout.



Patricia A. McClellan, Program Manager

12/6/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6-MPJ(18')	Client Project No.	: 729691.32010
Lab Sample No.	: 96-3990-02	Lab Project No.	: 96-3990
Date Sampled	: 11/08/96	Matrix	: Soil
Date Received	: 11/09/96	Lab File No.	: HALL1120\008F0101
Date Prepared	: 11/20/96	Method Blank	: RB112096
Date Analyzed	: 11/20/96	Dilution Factor	: 1.2
Percent Moisture	: 15.30		

Compound	CAS #	Concentration(ug/Kg)	RL(ug/Kg)
Vinyl Chloride	75-01-4	U	0.47
Chloroethane	75-00-3	U	0.47
1,1-Dichloroethene	75-35-4	U	0.47
Dichloromethane	75-09-2	U	0.47
trans-1,2-Dichloroethene	156-60-5	U	0.47
1,1-Dichloroethane	75-34-3	U	0.47
cis-1,2-Dichloroethene	156-59-4	U	0.47
1,1,1-Trichloroethane	71-55-6	U	0.47
Carbon Tetrachloride	56-23-5	U	0.47
Trichloroethene	79-01-6	U	0.47
1,1,2-Trichloroethane	79-00-5	U	0.47
Tetrachloroethene	127-18-4	U	0.47
1,1,1,2-Tetrachloroethane	79-00-5	U	0.47
Chlorobenzene	108-90-7	U	0.5
1,1,2,2-Tetrachloroethane	79-34-5	U	0.64
2-Chlorotoluene	95-49-8	U	0.47
Chlorotoluene	106-49-8	U	0.47
1,3-Dichlorobenzene	541-73-1	U	0.47
1,2-Dichlorobenzene	95-50-1	U	0.47

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 93% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPL(14-18) Client Project Number : 729691.32010
Lab Sample Number : 96-3996-09 Lab Work Order : 96-3996
Date Sampled : 11/9/96 Matrix : SOIL
Date Received : 11/11/96 Lab File Number(s) : TVB11113009
Date Prepared : 11/13/96 Method Blank : MB1111396
FID Dilution Factor : 1.0 Soil Extracted? : NO
PID Dilution Factor : 1.0 Soil Moisture : 14.09%

Compound Name	Cas Number	Analysis Date	Sample* Concentration	RL *	Units
TVH-Gasoline	---	NA	NA	NA	NA
Benzene	71-43-2	11/13/96	U	0.5	ug/kg
Toluene	108-88-3	11/13/96	U	0.5	ug/kg
Chlorobenzene	108-90-7	11/13/96	U	0.5	ug/kg
Ethyl Benzene	100-41-4	11/13/96	U	0.5	ug/kg
Total Xylenes (m,p,o)	1330-20-7	11/13/96	U	0.5	ug/kg
1,3,5-Trimethylbenzene	108-67-8	11/13/96	U	0.5	ug/kg
1,2,4-Trimethylbenzene	95-63-6	11/13/96	U	0.5	ug/kg
1,2,3-Trimethylbenzene	526-73-8	11/13/96	U	0.5	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	11/13/96	U	0.6	ug/kg
FID Surrogate Recovery:	NA			50%-150%	(Lim
PID Surrogate Recovery:	94%			50%-150%	(Li

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: * = Dry Basis

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.

RL = Reporting Limit.

NA = Not Available/Not Applicable.

PID = Photoionization detector.

FID = Flame ionization detector.

TVH = Total Volatile Hydrocarbons.

Analyst

Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: LF6-MPL(14-18)	Client Project No.	: 729691.32010
Lab Sample No.	: 96-3996-09	Lab Work Order	: 96-3996
Date Sampled	: 11/9/96	EPA Method No.	: 602/8020
Date Received	: 11/11/96	Matrix	: WATER
Date Prepared	: 11/13/96	Lab File Number(s)	: TVB11113010, 11
Date Analyzed	: 11/13/96	Method Blank	: MB1111396
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L)		Comments
			MS	MSD	
Benzene	20.0	0.0	20.6	21.2	
Toluene	20.0	0.0	19.6	20.3	
Chlorobenzene	20.0	0.0	19.2	19.8	
Ethylbenzene	20.0	0.0	19.7	20.4	
m,p-Xylene	20.0	0.0	19.8	21.3	
o-Xylene	20.0	0.0	19.8	22.1	
1,3,5-TMB	20.0	0.0	19.9	21.1	
1,2,4-TMB	20.0	0.0	19.4	21.5	
1,2,3-TMB	20.0	0.0	19.1	21.0	
1,2,3,4-TeMB	20.0	0.0	18.8	20.2	
Surrogate	100.0	94%	96%	99%	% RECOVERY

Compound	MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits		
				RPD	%REC	
Benzene	103.0	106.0	2.9	18	62	129
Toluene	98.0	101.5	3.5	25	55	133
Chlorobenzene	96.0	99.0	3.1	9	66	122
Ethylbenzene	98.5	102.0	3.5	15	60	127
m,p-Xylene	99.0	106.5	7.3	20	44	146
o-Xylene	99.0	110.5	11.0	16	57	131
1,3,5-TMB	99.5	105.5	5.9	16	63	129
1,2,4-TMB	97.0	107.5	10.3	16	55	136
1,2,3-TMB	95.5	105.0	9.5	13	64	127
1,2,3,4-TeMB	94.0	101.0	7.2	23	53	132
Surrogate	96.0	99.0	NA	NA	82	115

= Limits established 10/1/96,HDM

* = Values outside of QC limits.

RPD: 0 out of (10) outside limits.

Spike Recovery: 0 out of (20) outside limits.

Comments:

K. Hallman
Analyst

Amelia
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : LF6-MPL(14-18) Client Project No. : 729691-32010
Lab Sample No. : 96-3996-09 Lab Project No. : 96-3996
Date Sampled : 11/09/96 Matrix : SOIL
Date Received : 11/11/96 Lab File No. : HALL1120\011F0101
Date Prepared : 11/20/96 Method Blank : RB112096
Date Analyzed : 11/20/96 Dilution Factor : 1.2
Percent Moisture : 14.09

Compound	CAS #	Concentration(ug/Kg)	RL(ug/Kg)
Vinyl Chloride	75-01-4	U	0.46
Chloroethane	75-00-3	U	0.46
1,1-Dichloroethene	75-35-4	U	0.46
Dichloromethane	75-09-2	U	0.46
trans-1,2-Dichloroethene	156-60-5	U	0.46
1,1-Dichloroethane	75-34-3	U	0.46
cis-1,2-Dichloroethene	156-59-4	U	0.46
1,1,1-Trichloroethane	71-55-6	U	0.46
Carbon Tetrachloride	56-23-5	U	0.46
Trichloroethene	79-01-6	U	0.46
1,1,2-Trichloroethane	79-00-5	U	0.46
Tetrachloroethene	127-18-4	U	0.46
1,1,1,2-Tetrachloroethane	79-00-5	U	0.46
Chlorobenzene	108-90-7	U	0.49
1,1,2,2-Tetrachloroethane	79-34-5	U	0.63
2-Chlorotoluene	95-49-8	U	0.46
4-Chlorotoluene	106-49-8	U	0.46
1,3-Dichlorobenzene	541-73-1	U	0.46
1,2-Dichlorobenzene	95-50-1	U	0.46

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 90% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW3996.XLS; 11/25/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : LF6-MPL(14-18)MS Client Project No. : 729691-32010
Lab Sample No. : 96-3996-09MS Lab Project No. : 96-3996
Date Sampled : 11/09/96 Matrix : SOIL
Date Received : 11/11/96 Lab File No. : HALL1120\012F0101
Date Prepared : 11/20/96 Method Blank : RB112096
Date Analyzed : 11/20/96 Dilution Factor : 1.1
Percent Moisture : 14.09

Compound	CAS #	Concentration(ug/Kg)	RL(ug/Kg)
Vinyl Chloride	75-01-4	21	0.46
Chloroethane	75-00-3	22	0.46
1,1-Dichloroethene	75-35-4	23	0.46
Dichloromethane	75-09-2	22	0.46
trans-1,2-Dichloroethene	156-60-5	26	0.46
1,1-Dichloroethane	75-34-3	25	0.46
cis-1,2-Dichloroethene	156-59-4	25	0.46
1,1,1-Trichloroethane	71-55-6	26	0.46
Carbon Tetrachloride	56-23-5	26	0.46
Trichloroethene	79-01-6	26	0.46
1,1,2-Trichloroethane	79-00-5	23	0.46
Tetrachloroethene	127-18-4	25	0.46
1,1,1,2-Tetrachloroethane	79-00-5	23	0.46
Chlorobenzene	108-90-7	25	0.48
1,1,2,2-Tetrachloroethane	79-34-5	19	0.62
2-Chlorotoluene	95-49-8	23	0.46
1-Chlorotoluene	106-49-8	22	0.46
1,3-Dichlorobenzene	541-73-1	24	0.46
1,2-Dichlorobenzene	95-50-1	22	0.46

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 107% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW3996.XLS; 11/25/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : LF6-MPL(14-18)MSD Client Project No. : 729691-32010
Lab Sample No. : 96-399609MSD Lab Project No. : 96-3996
Date Sampled : 11/09/96 Matrix : SOIL
Date Received : 11/11/96 Lab File No. : HALL1120\013F010
Date Prepared : 11/20/96 Method Blank : RB112096
Date Analyzed : 11/20/96 Dilution Factor : 1.2
Percent Moisture : 14.09

Compound	CAS #	Concentration(ug/Kg)	RL(ug/Kg)
Vinyl Chloride	75-01-4	22	0.47
Chloroethane	75-00-3	22	0.47
1,1-Dichloroethene	75-35-4	23	0.47
Dichloromethane	75-09-2	22	0.47
trans-1,2-Dichloroethene	156-60-5	21	0.47
1,1-Dichloroethane	75-34-3	25	0.47
cis-1,2-Dichloroethene	156-59-4	25	0.47
1,1,1-Trichloroethane	71-55-6	25	0.47
Carbon Tetrachloride	56-23-5	25	0.47
Trichloroethene	79-01-6	26	0.47
1,1,2-Trichloroethane	79-00-5	23	0.47
Tetrachloroethene	127-18-4	25	0.47
1,1,1,2-Tetrachloroethane	79-00-5	22	0.47
Chlorobenzene	108-90-7	24	0.49
1,1,2,2-Tetrachloroethane	79-34-5	20	0.64
2-Chlorotoluene	95-49-8	24	0.47
4-Chlorotoluene	106-49-8	22	0.47
1,3-Dichlorobenzene	541-73-1	21	0.47
1,2-Dichlorobenzene	95-50-1	20	0.47

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 107% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW3996.XLS; 11/25/96

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Total Recoverable Petroleum Hydrocarbons

Date Sampled : 11/9/96
Date Received : 11/11/96
Date Prepared : 11/13/96
Date Analyzed : 11/13/96

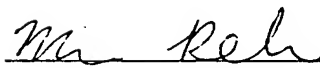
Client Project ID. : 729691-32010
Lab Project Number : 96-3996
Method : EPA 418.1

<u>Evergreen Sample #</u>	<u>Client Sample ID.</u>	<u>Matrix</u>	<u>TRPH</u>	<u>Units</u>
96-3996-09	LF6-MPL (14'-18')	Soil	<3.9	mg/Kg
96-3996-09 Duplicate	LF6-MPL (14'-18') Duplicate	Soil	<3.9	mg/Kg

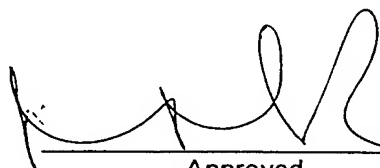
Method Blank (11/13/96) subtracted

3.4 mg/Kg

Results reported on a dry weight basis.



Analyst



Approved

HUFFMAN**LABORATORIES, INC.***Quality Analytical Services Since 1936*

4630 Indiana Street • Golden, CO 80403

Phone: (303) 278-4455 • FAX: (303) 278-7012

DATE 12/ 76
LAB# 234
P.O. SE
RECD 11/ 76CUSTOMER #:
02604**ANALYSIS REPORT**PATTY MC CLELLEN
EVERGREEN ANALYTICAL, INC
4036 YOUNGFIELD STREET
WHEAT RIDGE CO 80033

P.O. # 013549 & 013550/PROJ 96-3990 & 96-3996

SEQUENCE/ SAMPLE ID	01 LF6-MPJ (18')	02 LF6-MPL (14-18)	03 ST24-MPF(16-18)
CARBONATE C---%	- - - <0.02 - - -	- - - <0.02 - - -	- - - <0.02
TOTAL CARBON--%	- - - <0.05 - - -	- - - <0.05 - - -	- - - <0.05
ORGANIC C-----%	- - - <0.05 - - -	- - - <0.05 - - -	- - - <0.05

THE SAMPLES ARE NOT HOMOGENEOUS.

WORK ORDER Summary

15-Nov-96

Report To: Dave Moutoux

Client Project ID: 729691.32010

Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Phone: (303) 831-8100

FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-4033-01K	ST24-MPD(D)	Anions by IC Cl,NO2,NO3,SO4		Groundwater	D4	13-Nov-96	14-Nov-96	28-Nov-96	15-Nov-96
96-4033-02K	ST24-MPH(S)	Anions by IC Cl,NO2,NO3,SO4						28-Nov-96	15-Nov-96
96-4033-03K	W81	Anions by IC Cl,NO2,NO3,SO4						28-Nov-96	15-Nov-96
96-4033-04K	LF6-MPM	Anions by IC Cl,NO2,NO3,SO4						28-Nov-96	15-Nov-96
96-4033-05K	W22	Anions by IC Cl,NO2,NO3,SO4						28-Nov-96	15-Nov-96
96-4033-06K	W1	Anions by IC Cl,NO2,NO3,SO4						28-Nov-96	15-Nov-96
96-4033-01D	ST24-MPD(D)	BTEX (Parsons List)			2			28-Nov-96	27-Nov-96
96-4033-02D	ST24-MPH(S)	BTEX (Parsons List)						28-Nov-96	27-Nov-96
96-4033-03D	W81	BTEX (Parsons List)						28-Nov-96	27-Nov-96
96-4033-04D	LF6-MPM	BTEX (Parsons List)						28-Nov-96	27-Nov-96
96-4033-05D	W22	BTEX (Parsons List)						28-Nov-96	27-Nov-96
96-4033-06D	W1	BTEX (Parsons List)						28-Nov-96	27-Nov-96
96-4033-07A	Trip Blank	BTEX (Parsons List)		Water	9			28-Nov-96	27-Nov-96
96-4033-01H	ST24-MPD(D)	Methane		Groundwater	2	13-Nov-96		28-Nov-96	27-Nov-96
96-4033-02H	ST24-MPH(S)	Methane						28-Nov-96	27-Nov-96
96-4033-03H	W81	Methane						28-Nov-96	27-Nov-96
96-4033-04H	LF6-MPM	Methane						28-Nov-96	27-Nov-96
96-4033-05H	W22	Methane						28-Nov-96	27-Nov-96

= Special list. See sample comments or test information.

HT = Holding Time expiration date.

11/15/96

Evergreen Analytical, Inc.

96-4033

WORK ORDER Summary

15-Nov-96

Report To: Dave Moutoux

Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.32010

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	ITT
96-4033-06H	W1	Methane		Groundwater	2	13-Nov-96	14-Nov-96	28-Nov-96	27-Nov-96
96-4033-01A	ST24-MPD(D)	Purgeable Halocarbons 8010			9			28-Nov-96	27-Nov-96
96-4033-02A	ST24-MPH(S)	Purgeable Halocarbons 8010						28-Nov-96	27-Nov-96
96-4033-03A	W81	Purgeable Halocarbons 8010						28-Nov-96	27-Nov-96
96-4033-04A	LF6-MPM	Purgeable Halocarbons 8010						28-Nov-96	27-Nov-96
96-4033-05A	W22	Purgeable Halocarbons 8010						28-Nov-96	27-Nov-96
96-4033-06A	W1	Purgeable Halocarbons 8010						28-Nov-96	27-Nov-96
96-4033-07A	Trip Blank	Purgeable Halocarbons 8010		Water				28-Nov-96	27-Nov-96
96-4033-01K	ST24-MPD(D)	Total Alkalinity		Groundwater	D4	13-Nov-96		28-Nov-96	27-Nov-96
96-4033-02K	ST24-MPH(S)	Total Alkalinity						28-Nov-96	27-Nov-96
96-4033-03L	W81	Total Alkalinity						28-Nov-96	27-Nov-96
96-4033-04L	LF6-MPM	Total Alkalinity						28-Nov-96	27-Nov-96
96-4033-05L	W22	Total Alkalinity						28-Nov-96	27-Nov-96
96-4033-06L	W1	Total Alkalinity						28-Nov-96	27-Nov-96
96-4033-01D	ST24-MPD(D)	TVH (Gasoline)			2			28-Nov-96	27-Nov-96
96-4033-02D	ST24-MPH(S)	TVH (Gasoline)						28-Nov-96	27-Nov-96
96-4033-03D	W81	TVH (Gasoline)						28-Nov-96	27-Nov-96
96-4033-04D	LF6-MPM	TVH (Gasoline)						28-Nov-96	27-Nov-96
96-4033-05D	W22	TVH (Gasoline)						28-Nov-96	27-Nov-96
96-4033-06D	W1	TVH (Gasoline)						28-Nov-96	27-Nov-96
96-4033-07A	Trip Blank	TVH (Gasoline)		Water	9			28-Nov-96	27-Nov-96

CHAIN OF CUSTODY RECORD // ANALYTICAL SERVICES REQUEST

COMPANY THOMPSONS ES
 ADDRESS 1700 Broadway
 CITY DENVER STATE CO ZIP 80202
 PHONE# (303) 831-8100
 Sampler Name: BOB MAGGEL
 (signature) _____
 (print) BOB MAGGEL

PRINT

Please
PRIN
all information:

CLIENT
SAMPLE

[illegible]

ST24-MPD	11/13	07K
ST24-MPHS	11/13	100C
W81	11/13	144S
116-MPM	11/13	1630C
W22	11/13	1750C
W21	11/13 15 ⁴ /13	1830

T. O. Blanche

Instructions:

PK:	not received:	received:
01L+02L		

Relinquished by: (Signature)

Date/Time	Received by: (Signature)
-----------	--------------------------

Date/T

Relinquished by: (Signature)

Date/Time:

Received by: (Signature)

Date/Time

U.S. 10

— 122 —

1780

11/18/96

100

01111 60129

...ance of: (c) ...

קצות השולחן

100/1000: ~

11/15/20

2/10/20

11/11/18

11

017

0017

04:00

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
84

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : W81 Client Project Number : 729691.32010
Lab Sample Number : 96-4033-03 Lab Work Order : 96-4033
Date Sampled : 11/13/96 Matrix : WATER
Date Received : 11/14/96 Lab File Number(s) : TVB31115012
Date Prepared : 11/15/96 Method Blank : MB3111596
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/15/96	U	0.1	mg/L
Benzene	71-43-2	11/15/96	0.9	0.4	ug/L
Toluene	108-88-3	11/15/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/15/96	10	0.4	ug/L
Ethyl Benzene	100-41-4	11/15/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/15/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/15/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/15/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/15/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/15/96	1.3	0.5	ug/L
FID Surrogate Recovery:		96%		70%-126%	(L)
PID Surrogate Recovery:		93%		76%-127%	(L)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPM Client Project Number : 729691.32010
Lab Sample Number : 96-4033-04 Lab Work Order : 96-4033
Date Sampled : 11/13/96 Matrix : WATER
Date Received : 11/14/96 Lab File Number(s) : TVB31115017
Date Prepared : 11/15/96 Method Blank : MB3111596
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/15/96	U	0.1	mg/L
Benzene	71-43-2	11/15/96	U	0.4	ug/L
Toluene	108-88-3	11/15/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/15/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/15/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/15/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/15/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/15/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/15/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/15/96	U	0.5	ug/L
Surrogate Recovery:		90%		70%-126%	(Limits)
Surrogate Recovery:		88%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : W22 Client Project Number : 729691.32010
Lab Sample Number : 96-4033-05 Lab Work Order : 96-4033
Date Sampled : 11/13/96 Matrix : WATER
Date Received : 11/14/96 Lab File Number(s) : TVB31115018
Date Prepared : 11/15/96 Method Blank : MB3111596
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/15/96	U	0.1	mg/L
Benzene	71-43-2	11/15/96	U	0.4	ug/L
Toluene	108-88-3	11/15/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/15/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/15/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/15/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/15/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/15/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/15/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/15/96	U	0.5	ug/L
FID Surrogate Recovery: 88% 70%-126% (Lin					
PID Surrogate Recovery: 85% 76%-127% (Lin					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : W1 Client Project Number : 729691.32010
Lab Sample Number : 96-4033-06 Lab Work Order : 96-4033
Date Sampled : 11/13/96 Matrix : WATER
Date Received : 11/14/96 Lab File Number(s) : TVB31115019
Date Prepared : 11/15/96 Method Blank : MB3111596
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/15/96	U	0.1	mg/L
Benzene	71-43-2	11/15/96	U	0.4	ug/L
Toluene	108-88-3	11/15/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/15/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/15/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/15/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/15/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/15/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/15/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/15/96	U	0.5	ug/L
Surrogate Recovery:		90%		70%-126%	(Limits)
Surrogate Recovery:		86%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hallman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB3111596 Client Project Number : 729691.32010
Date Prepared : 11/15/96 Lab Work Order : 96-4033
Dilution Factor : 1.0 Matrix : WATER
Lab File Number : TVB31115009

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/15/96	U	0.1	mg/L
Benzene	71-43-2	11/15/96	U	0.4	ug/L
Toluene	108-88-3	11/15/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/15/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/15/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/15/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/15/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/15/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/15/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/15/96	U	0.5	ug/L
FID Surrogate Recovery: 96% 70%-126% (Lir					
PID Surrogate Recovery: 93% 76%-127% (L					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB3111696 Client Project Number : 729691.32010
Date Prepared : 11/16/96 Lab Work Order : 96-4033
Dilution Factor : 1.0 Matrix : WATER
Lab File Number : TVB31115027

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/16/96	U	0.1	mg/L
Benzene	71-43-2	11/16/96	U	0.4	ug/L
Toluene	108-88-3	11/16/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/16/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/16/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/16/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/16/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/16/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/16/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/16/96	U	0.5	ug/L
PID Surrogate Recovery:		93%		70%-126%	(Limits)
Surrogate Recovery:		91%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB2111896 Client Project Number : 729691.32010
Date Prepared : 11/18/96 Lab Work Order : 96-4033
Dilution Factor : 1.0 Matrix : WATER
Lab File Number : TVB21118003

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	11/18/96	U	0.1	mg/L
Benzene	71-43-2	11/18/96	U	0.4	ug/L
Toluene	108-88-3	11/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/18/96	U	0.5	ug/L
FID Surrogate Recovery:		92%		70%-126%	(Li
PID Surrogate Recovery:		97%		76%-127%	(L

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

A. McCallen
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : TRIP BLANK Client Project Number : 729691.32010
Lab Sample Number : 96-4033-07 Lab Work Order : 96-4033
Date Sampled : N/A Matrix : WATER
Date Received : 11/14/96 Lab File Number(s) : TVB21118036
Date Prepared : 11/18/96 Method Blank : MB2111896
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/18/96	U	0.1	mg/L
Benzene	71-43-2	11/18/96	U	0.4	ug/L
Toluene	108-88-3	11/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/18/96	U	0.5	ug/L
Surrogate Recovery:		94%		70%-126%	(Limits)
Surrogate Recovery:		94%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: W81	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4033-03	Lab Work Order	: 96-4033
Date Sampled	: 11/13/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 11/14/96	Matrix	: WATER
Date Prepared	: 11/15/96	Lab File Number(s)	: TVB31115013,14
Date Analyzed	: 11/15/96	Method Blank	: MB3111596
Instrument Name	: TVHBTEX3	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#) Limits
					%REC
Gasoline	2.00	0.00	1.80	89.9%	55 - 128
Surrogate **	---	---	---	97%	70 - 130

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC Limits	
					RPD	%REC
Gasoline	2.00	1.72	86.2%	4.3	50	50 - 150
Surrogate **	---	---	94%	NA	NA	70 - 130

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:

NA = Not analyzed/not applicable.

* = Values outside of QC limits.

** = 1,2,4-Trichlorobenzene

Comments:

M. Blecha
Analyst

K. Hallman
Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: W81	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4033-03	Lab Work Order	: 96-4033
Date Sampled	: 11/13/96	EPA Method No.	: 602/8020
Date Received	: 11/14/96	Matrix	: WATER
Date Prepared	: 11/15/96	Lab File Number(s)	: TVB31115015,16
Date Analyzed	: 11/15/96	Method Blank	: MB3111596
Instrument Name	: TVHBTEX3	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L)		Comments
			MS	MSD	
Benzene	20.0	0.9	18.5	18.8	
Toluene	20.0	0.0	16.8	17.3	
Chlorobenzene	20.0	10.0	27.2	27.8	
Ethylbenzene	20.0	0.0	17.1	17.6	
m,p-Xylene	20.0	0.0	17.4	17.7	
o-Xylene	20.0	0.0	16.8	17.4	
1,3,5-TMB	20.0	0.0	17.8	19.5	
1,2,4-TMB	20.0	0.0	16.7	17.2	
1,2,3-TMB	20.0	0.0	17.7	18.5	
1,2,3,4-TeMB	20.0	1.3	17.3	18.3	
Surrogate	100.0	93%	93%	92%	

Compound	MS % RECOVERY	MSD % RECOVERY	RPD	QC Limits		
				RPD	%REC	
Benzene	88.0	89.5	1.7	25	39	150
Toluene	84.0	86.5	2.9	25	46	148
Chlorobenzene	86.0	89.0	3.4	25	55	135
Ethylbenzene	85.5	88.0	2.9	25	32	160
m,p-Xylene	87.0	88.5	1.7	25	25	150
o-Xylene	84.0	87.0	3.5	25	25	150
1,3,5-TMB	89.0	97.5	9.1	25	25	150
1,2,4-TMB	83.5	86.0	2.9	25	25	150
1,2,3-TMB	88.5	92.5	4.4	25	25	150
1,2,3,4-TeMB	80.0	85.0	6.1	25	25	150
Surrogate	93.0	92.0	NA	NA	70	130

* = Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments: _____

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: <u>LCS3111596-GAS</u>	Matrix	: <u>WATER</u>
Date Prepared	: <u>11/15/96</u>	Method Numbers	: <u>EPA 5030/8015 Modified</u>
Date Analyzed	: <u>11/15/96</u>	Instrument Name	: <u>TVHBTEX3</u>
Lab File Number(s)	: <u>TVB31115007</u>		

<u>Compound Name</u>	<u>Theoretical Concentration (mg/L)</u>	<u>LCS Concentration (mg/L)</u>	<u>LCS % Recovery</u>	<u>QC Limit % Recovery</u>
Gasoline	2.00	1.98	99.2	50 - 150
<hr/>				
Surrogate Recovery:		105%		70 - 130

QUALIFIERS

B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA = Not Available/Not Applicable.

M. Richa
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St.
Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number : LCS3111596-BTEX
Date Extracted/Prepared : 11/15/96
Date Analyzed : 11/15/96
Spike Amount (ug/L) : 20.0

Dilution Factor : 1.00
Method : 602/8020
Matrix : Water
Lab File No. : TVB31115008

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit % Recovery
Benzene	71-43-2	18.5	92.5	50 - 150
Toluene	108-88-3	18.2	91.0	50 - 150
Chlorobenzene	108-90-7	16.8	84.0	50 - 150
Ethyl Benzene	100-41-4	18.3	91.5	50 - 150
m,p-Xylene	108-38-3	36.0	90.0	50 - 150
o-Xylene	106-42-3			
m-Xylene	95-47-6	18.2	91.0	50 - 150
p-Xylene	1634-04-4	18.6	93.0	50 - 150
1,3,5-Trimethylbenzene	108-67-8	18.9	94.5	50 - 150
1,2,4-Trimethylbenzene	95-63-6	17.5	87.5	50 - 150
1,2,3-Trimethylbenzene	526-73-8	21.1	105.5	50 - 150
1,2,3,4-Tetramethylbenzene	488-23-3	18.8	94.0	50 - 150
Surrogate Recovery:		96%		70 - 130

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:

E = Extrapolated value. Value exceeds that of the calibration range.

U = Compound analyzed for, but not detected.

B = Compound found in blank and sample. Compare blank and sample data.

NA = Not available/Not analyzed.

M. Blicher
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: <u>LCS2111896-GAS</u>	Matrix	: <u>WATER</u>
Date Prepared	: <u>11/18/96</u>	Method Numbers	: <u>EPA 5030/8015 Modified</u>
Date Analyzed	: <u>11/18/96</u>	Instrument Name	: <u>TVHBTEX2</u>
Lab File Number(s)	: <u>TVB21118013</u>		

<u>Compound Name</u>	<u>Theoretical Concentration (mg/L)</u>	<u>LCS Concentration (mg/L)</u>	<u>LCS % Recovery</u>	<u>QC Limit % Recovery</u>
Gasoline	2.00	2.32	115.9	81 - 128
Surrogate Recovery:		125%		70 - 126

QUALIFIERS

B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA = Not Available/Not Applicable.
** = Limits established 10/1/96 for TVHBTEX2. MAB

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St.
Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number : LCS2111896-BTEX
Date Extracted/Prepared : 11/18/96
Date Analyzed : 11/18/96
Spike Amount (ug/L) : 20.0

Dilution Factor : 1.00
Method : 602/8020
Matrix : Water
Lab File No. : TVB221118014

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	20.6	103.0	75 - 116
Toluene	108-88-3	20.0	100.0	75 - 118
Chlorobenzene	108-90-7	18.2	91.0	73 - 115
Ethyl Benzene	100-41-4	19.7	98.5	80 - 122
m,p-Xylene	108-38-3	38.1	95.3	76 - 120
Xylene	106-42-3			
	95-47-6	20.0	100.0	76 - 118
	1634-04-4	20.5	102.5	75 - 115
1,3,5-Trimethylbenzene	108-67-8	19.6	98.0	64 - 118
1,2,4-Trimethylbenzene	95-63-6	18.1	90.5	75 - 111
1,2,3-Trimethylbenzene	526-73-8	22.6	113.0	82 - 127
1,2,3,4-Tetramethylbenzene	488-23-3	20.6	103.0	72 - 131
Surrogate Recovery:		100%		76 - 127

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:

E = Extrapolated value. Value exceeds that of the calibration range.
U = Compound analyzed for, but not detected.
B = Compound found in blank and sample. Compare blank and sample data.
NA = Not available/Not analyzed.
= Limits established 10/1/96 for TVHBTEX2. MAB

Analyst

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 8010 Chlorinated VOC's Method Blank Report

Method Blank : RB112196 Client Project No. : 729691.32010
Date Prepared : 11/21/96 Lab Project No. : 96-4033
Date Analyzed : 11/21/96 Lab File No. : HALL1121\004F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 81% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4033.XLS; 11/26/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Method Blank Report

Method Blank : RB112596 Client Project No. : 729691.32010
Date Prepared : 11/25/96 Lab Project No. : 96-4033
Date Analyzed : 11/25/96 Lab File No. : HALL1125\004F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 85% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4033.XLS; 11/26/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: W81	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4033-03	Lab Project No.	: 96-4033
Date Sampled	: 11/13/96	Matrix	: Water
Date Received	: 11/14/96	Lab File No.	: HALL1125\005F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	4.8	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	6.5	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	0.49 J	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 94% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4033.XLS; 11/26/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6-MPM	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4033-04	Lab Project No.	: 96-4033
Date Sampled	: 11/13/96	Matrix	: Water
Date Received	: 11/14/96	Lab File No.	: HALL1121\020F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/21/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	2.7	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	3.8	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	1.1	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
3-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 82% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4033.XLS; 11/28/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : W22
Lab Sample No. : 96-4033-05
Date Sampled : 11/13/96
Date Received : 11/14/96
Date Prepared : 11/21/96
Date Analyzed : 11/21/96
Client Project No. : 729691.32010
Lab Project No. : 96-4033
Matrix : Water
Lab File No. : HALL1121\021F0101
Method Blank : RB112196
Dilution Factor : 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.4
1,1,2,2-Tetrachloroethane	79-34-5	U	0.42
2-Chlorotoluene	95-49-8	U	0
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 79% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4033.XLS; 11/26/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: W1	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4033-06	Lab Project No.	: 96-4033
Date Sampled	: 11/13/96	Matrix	: Water
Date Received	: 11/14/96	Lab File No.	: HALL1121\022F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/21/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
1-Chlorotoluene	106-49-8	U	0.4
1,2-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 72% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4033.XLS; 11/28/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: Trip Blank	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4033-07	Lab Project No.	: 96-4033
Date Sampled	: 11/13/96	Matrix	: Water
Date Received	: 11/14/96	Lab File No.	: HALL1121\023F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/21/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 73% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4033.XLS; 11/26/96

Method 8010 Quality Control Samples

Date Performed: 11/21/96

Reference Standard: V832

Analyte	M	Method	Sample	Sample	Sample	Spike	Control	Spike	Amt	RPD	Spike Recoveries			QC Recovery Range		
											Sample	Dup	#	% L	% H	Low - High
Vinyl Chloride	W				13.283	14.878	15.321	20.0	20.0	11.3	66%	74%	77%	28	163	5.60 - 32.60
Chloroethane	*				16.436	17.331	17.177	20.0	20.0	5.3	82%	87%	86%	48	137	9.20 - 27.40
1,1-Dichloroethene	*				17.049	17.216	18.277	20.0	20.0	1.0	85%	86%	91%	28	167	5.60 - 33.40
Dichloromethane	*				16.163	16.26	16.526	20.0	20.0	0.6	81%	81%	83%	25	162	5.00 - 32.40
trans-1,2-Dichloroethene	*				20.881	20.771	21.672	20.0	20.0	0.5	104%	104%	108%	38	155	7.60 - 31.00
1,1-Dichloroethane	*				18.409	18.937	18.876	20.0	20.0	2.8	92%	95%	94%	47	132	9.40 - 28.40
cis-1,2-Dichloroethene	*				18.726	18.512	19.425	20.0	20.0	1.1	94%	93%	97%	-	-	-
1,1,1-Trichloroethane	*				18.083	18.089	19.867	20.0	20.0	0.0	90%	90%	99%	41	138	8.20 - 27.60
Carbon Tetrachloride	*				18.54	18.589	19.370	20.0	20.0	0.3	93%	93%	97%	43	143	8.60 - 28.60
Trichloroethene	W				19.47	19.231	20.550	20.0	20.0	1.2	97%	96%	103%	35	146	7.00 - 29.20
1,1,2-Trichloroethane	W				19.725	19.42	19.498	20.0	20.0	1.6	99%	97%	97%	39	136	7.80 - 27.20
Tetrachloroethene	*				18.183	17.756	18.182	20.0	20.0	2.4	91%	89%	91%	26	162	5.20 - 32.40
1,1,1,2-Tetrachloroethane	*				16.532	15.92	17.703	20.0	20.0	3.8	83%	80%	89%	-	-	-
Chlorobenzene	*				17.691	18.375	19.046	20.0	20.0	3.8	88%	92%	95%	1	150	0.16 - 30.00
1,1,2,2-Tetrachloroethane	*				19.769	20.198	20.962	20.0	20.0	2.1	99%	101%	105%	8	184	1.60 - 36.80
2-Chlorotoluene	*				17.15	16.509	17.441	20.0	20.0	3.8	86%	83%	87%	-	-	-
4-Chlorotoluene	*				16.472	16.38	16.153	20.0	20.0	0.6	82%	82%	81%	-	-	-
1,3-Dichlorobenzene	*				16.387	16.588	16.877	20.0	20.0	1.2	82%	83%	84%	7	187	1.40 - 37.40
1,2-Dichlorobenzene	*				12.762	14.096	15.866	20.0	20.0	9.9	64%	70%	79%	0	208	0.00 - 41.60

M = Applicable matrices. (* = Soil and Water. w = Water only.)

= Marks a spike recovery out of limits.

If recovery is outside method limit, marked with "###".

If recovery is outside a guideline, marked with "w".

If the sample spike recovery is outside the limit and the control spike is outside the limit also, the control is marked with "###" or "w".

Notes on recovery limits:

All spiked analytes must be detected even if low limit is 0.

For analytes not listed in the method, recovery limits of 50-150% will be used as guidelines until limits can be established.

Corrective Actions:

Unacceptable sample spike recovery requires acceptable control spike recovery. If both recoveries are outside limits, corrective action must be taken. One recovery outside limits and the other acceptable, is a warning. Repeated failure requires corrective action. Recoveries outside guidelines should be compared to historical data available to determine if corrective action is required.

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form
Method Blank Report

Method Blank Number	: GB112196	Client Project No.	: 729691.32010
Date Extracted/Prepared	: 11/21/96	Lab Work Order	: 96-4033
Date Analyzed	: 11/21/96	Dilution Factor	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS1121002

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers

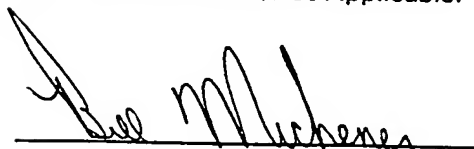
E = Extrapolated value.


U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number : W81 Client Project No. : 729691.32010
Lab Sample Number : 96-4033-03 Lab Work Order : 96-4033
Date Sampled : 11/13/96 Dilution Factor : 50.00
Date Received : 11/14/96 Method : RSKSOP-175M
Date Extracted/Prepared : 11/21/96 Matrix : Water
Date Analyzed : 11/21/96 Lab File No. : GAS1121010

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.7	0.1

Temperature	: 74 F	Saturation	Meth	0.164163893
Amount Injected	: 0.01 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.515304837
Head space created	: 4 ml	in Head Space		
Methane Area	: 76.351 ug			

Atomic weight(Methane) : 16 g

Qualifiers


E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

1 = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPM	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4033-04	Lab Work Order	: 96-4033
Date Sampled	: 11/13/96	Dilution Factor	: 1.00
Date Received	: 11/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/21/96	Matrix	: Water
Date Analyzed	: 11/21/96	Lab File No.	: GAS1121011

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 74.2 F
Amount Injected	: 0.5 ml
Total Volume of Sample	: 43 ml
Head space created	: 4 ml
Methane Area	: 0 ug


Saturation	Meth
Concentration	
Concentration	Meth
in Head Space	

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPM	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4033-04Dup	Lab Work Order	: 96-4033
Date Sampled	: 11/13/96	Dilution Factor	: 1.00
Date Received	: 11/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/21/96	Matrix	: Water
Date Analyzed	: 11/21/96	Lab File No.	: GAS1121012

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 74.2 F	Saturation	Meth	0
Amount Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0
Head space created	: 4 ml	in Head Space		
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers


E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

A = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: W22	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4033-05	Lab Work Order	: 96-4033
Date Sampled	: 11/13/96	Dilution Factor	: 1.00
Date Received	: 11/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/21/96	Matrix	: Water
Date Analyzed	: 11/21/96	Lab File No.	: GAS1121013

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 74.3 F	Saturation	Meth
Amount Injected	: 0.5 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration	Meth
Head space created	: 4 ml	in Head Space	
Methane Area	: 0 ug		

Atomic weight(Methane) : 16 g

Qualifiers

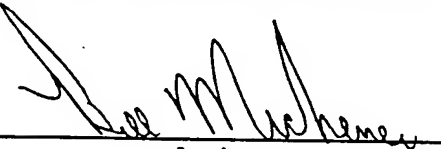
E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number : W1 Client Project No. : 729691.32010
Lab Sample Number : 96-4033-06 Lab Work Order : 96-4033
Date Sampled : 11/13/96 Dilution Factor : 1.00
Date Received : 11/14/96 Method : RSKSOP-175M
Date Extracted/Prepared : 11/21/96 Matrix : Water
Date Analyzed : 11/21/96 Lab File No. : GAS1121014

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 74.7 F	Saturation	Meth	0
Amount Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0
Head space created	: 4 ml	in Head Space		
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers


E = Extrapolated value.


U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

*A = Not Available/Not Applicable.


Analyst


Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane Gas Matrix Spike / Matrix Spike Duplicate Report

Client Sample No. : W22 Client Project No. : 729691.32010
Lab Sample No. : 96-4033-05 Lab Work Order : 96-4033
Date Sampled : 11/13/96 EPA Method No. : RSKSOP-175M
Date Received : 11/14/96 Matrix : Water
Date Prepared : 11/21/96 Method Blank : GB112196
Date Analyzed : 11/21/96 Lab File No's. : GAS1121022,023
E.A. MS/MSD Spike Source No. : 1886

Compound	Spike Added (ug)	Sample Concentration (ug)	MS Concentration (ug)	MS %REC	QC Limits %REC
Methane Gas	500	0	329	66	47-88

Compound	Spike Added (ug)	MSD Concentration (ug)	MSD %REC	RPD	QC Limits RPD	QC Limits %REC
Methane Gas	500	341	68	3.5	0-16.4	47-88


RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.


Notes

* = Values outside of QC limits.

NA = Not analyzed/not available

Note: The Spike was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.


Analyst


Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

**RSKSOP-175M Gas Method
Methane LCS Report Form**

LCS No. : LCS112196 EPA Method No. : RSKSOP-175M
Date Prepared : 11/21/96 Matrix : Water
Date Analyzed : 11/21/96 Method Blank : GB112196
E.A. LCS Source No. : 1886 Lab File No. : GAS1121006


Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	409	82	64-90

Spike Recovery: 0 out of (1) outside limits.

Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes

* = Values outside of QC limits.
NA = Not analyzed/not available.



Analyst



Approved

WORK ORDER Summary

19-Nov-96

Report To: Dave Moutoux

Client Project ID: 729691.32010

Parsons Engineering Science

1700 Broadway Suite 900

Denver, CO 80290

Phone: (303) 831-8100

FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-4047-01K	LF6 MPO	Anions by IC Cl,NO2,NO3,SO4		Water	D4	14-Nov-96	15-Nov-96	02-Dec-96	16-Nov-96
96-4047-02K	LF6 MPP	Anions by IC Cl,NO2,NO3,SO4						02-Dec-96	16-Nov-96
96-4047-03K	W 78	Anions by IC Cl,NO2,NO3,SO4						02-Dec-96	16-Nov-96
96-4047-04K	W 21	Anions by IC Cl,NO2,NO3,SO4						02-Dec-96	16-Nov-96
96-4047-05K	W 20	Anions by IC Cl,NO2,NO3,SO4						02-Dec-96	16-Nov-96
96-4047-07K	LF6 MPQ	Anions by IC Cl,NO2,NO3,SO4						02-Dec-96	16-Nov-96
96-4047-01D	LF6 MPO	BTEX (Parsons List)			2			02-Dec-96	28-Nov-96
96-4047-02D	LF6 MPP	BTEX (Parsons List)						02-Dec-96	28-Nov-96
96-4047-03D	W 78	BTEX (Parsons List)						02-Dec-96	28-Nov-96
96-4047-04D	W 21	BTEX (Parsons List)						02-Dec-96	28-Nov-96
96-4047-05D	W 20	BTEX (Parsons List)						02-Dec-96	28-Nov-96
96-4047-07D	LF6 MPQ	BTEX (Parsons List)						02-Dec-96	28-Nov-96
96-4047-08A	Trip Blank-5	BTEX (Parsons List)			9			02-Dec-96	28-Nov-96
96-4047-01H	LF6 MPO	Methane			2			02-Dec-96	28-Nov-96
96-4047-02H	LF6 MPP	Methane						02-Dec-96	28-Nov-96
96-4047-03H	W 78	Methane						02-Dec-96	28-Nov-96
96-4047-04H	W 21	Methane						02-Dec-96	28-Nov-96
96-4047-05H	W 20	Methane						02-Dec-96	28-Nov-96

= Special list. See sample comments or test information.

HT = Holding Time expiration date.

6/6/96

Evergreen Analytical, Inc.

96-4047

WORK ORDER Summary

19-Nov-96

Report To: Dave Moutoux

Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.32010

Phone: (303) 831-8100

FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-4047-07H	LF6 MPQ	Methane		Water	2	14-Nov-96	15-Nov-96	02-Dec-96	28-Nov-96
96-4047-01A	LF6 MPO	Purgeable Halocarbons 8010			9			02-Dec-96	28-Nov-96
96-4047-02A	LF6 MPP	Purgeable Halocarbons 8010						02-Dec-96	28-Nov-96
96-4047-03A	W 78	Purgeable Halocarbons 8010						02-Dec-96	28-Nov-96
96-4047-04A	W 21	Purgeable Halocarbons 8010						02-Dec-96	28-Nov-96
96-4047-05A	W 20	Purgeable Halocarbons 8010						02-Dec-96	28-Nov-96
96-4047-06A	W 2	Purgeable Halocarbons 8010						02-Dec-96	28-Nov-96
96-4047-07A	LF6 MPQ	Purgeable Halocarbons 8010						02-Dec-96	28-Nov-96
96-4047-08A	Trip Blank-5	Purgeable Halocarbons 8010						02-Dec-96	28-Nov-96
96-4047-01L	LF6 MPO	Total Alkalinity			D4			02-Dec-96	28-Nov-96
96-4047-02L	LF6 MPP	Total Alkalinity						02-Dec-96	28-Nov-96
96-4047-03L	W 78	Total Alkalinity						02-Dec-96	28-Nov-96
96-4047-04L	W 21	Total Alkalinity						02-Dec-96	28-Nov-96
96-4047-05L	W 20	Total Alkalinity						02-Dec-96	28-Nov-96
96-4047-07L	LF6 MPQ	Total Alkalinity						02-Dec-96	28-Nov-96
96-4047-01M	LF6 MPO	Total Organic Carbon						02-Dec-96	28-Nov-96
96-4047-02M	LF6 MPP	Total Organic Carbon						02-Dec-96	12-Dec-96
96-4047-03M	W 78	Total Organic Carbon						02-Dec-96	12-Dec-96
96-4047-04M	W 21	Total Organic Carbon						02-Dec-96	12-Dec-96
96-4047-01D	LF6 MPO	TVH (Gasoline)			2			02-Dec-96	12-Dec-96
96-4047-02D	LF6 MPP	TVH (Gasoline)						02-Dec-96	28-Nov-96
96-4047-03D	W 78	TVH (Gasoline)						02-Dec-96	28-Nov-96
96-4047-04D	W 21	TVH (Gasoline)						02-Dec-96	28-Nov-96

= Spk See sample comments or test information.

HT = Holding time expiration date.

WORK ORDER Summary

19-Nov-96

Report To: Dave Moutoux

Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.32010

Phone: (303) 831-8100

FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-4047-05D	W 20	TVH (Gasoline)		Water	2	14-Nov-96	15-Nov-96	02-Dec-96	28-Nov-96
96-4047-06D	W 2	TVH (Gasoline)						02-Dec-96	28-Nov-96
96-4047-07D	LF6 MPQ	TVH (Gasoline)						02-Dec-96	28-Nov-96
96-4047-08A	Trip Blank-5	TVH (Gasoline)			9			02-Dec-96	28-Nov-96

Person 5

Evergreen Analytical Inc.

4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

ADDRESS 1700 Broadway Suite 900
CITY Denver STATE CO ZIP 80290

PHONE# (303) 831-8100

Sampler Name: Bob Nager
(signature)
(print) BOB NAGER

PRINT
Please

all information:

CLIENT
SAMPLE

SAMPLE IDENTIFICATION	DATE SAMPLE
-----------------------	-------------

LF6 MPO	11/14/96	0730	13
LF6 MPP	11/14/96	0720	13
W78	11/14/96	1110	13
W21	11/14/96	1320	13
W30	11/14/96	1515	12
W2	11/14/96	1130	7
LF6 MPP	11/14/96	1645	12
TRIP BLANK	11/14/96		1

MATRIX		ANALYSIS REQUESTED															For Laboratory use only	
No. of Containers	Water-Drinking/Discharge/Ground (circle)	Oil / Sludge / Multi-phase	TCLP VOA/BNA/Pest/Herb/Metals (circle)	VOA 8260/8270/8280/8290/8300/8310/8320/8330/8340/8350/8360/8370/8380/8390/8400/8410/8420/8430/8440/8450/8460/8470/8480/8490/8500/8510/8520/8530/8540/8550/8560/8570/8580/8590/8600/8610/8620/8630/8640/8650/8660/8670/8680/8690/8700/8710/8720/8730/8740/8750/8760/8770/8780/8790/8800/8810/8820/8830/8840/8850/8860/8870/8880/8890/8900/8910/8920/8930/8940/8950/8960/8970/8980/8990/9000/9010/9020/9030/9040/9050/9060/9070/9080/9090/9100/9110/9120/9130/9140/9150/9160/9170/9180/9190/9200/9210/9220/9230/9240/9250/9260/9270/9280/9290/9300/9310/9320/9330/9340/9350/9360/9370/9380/9390/9400/9410/9420/9430/9440/9450/9460/9470/9480/9490/9500/9510/9520/9530/9540/9550/9560/9570/9580/9590/9600/9610/9620/9630/9640/9650/9660/9670/9680/9690/9700/9710/9720/9730/9740/9750/9760/9770/9780/9790/9800/9810/9820/9830/9840/9850/9860/9870/9880/9890/9900/9910/9920/9930/9940/9950/9960/9970/9980/9990/10000/10010/10020/10030/10040/10050/10060/10070/10080/10090/10100/10110/10120/10130/10140/10150/10160/10170/10180/10190/10200/10210/10220/10230/10240/10250/10260/10270/10280/10290/10300/10310/10320/10330/10340/10350/10360/10370/10380/10390/10400/10410/10420/10430/10440/10450/10460/10470/10480/10490/10500/10510/10520/10530/10540/10550/10560/10570/10580/10590/10600/10610/10620/10630/10640/10650/10660/10670/10680/10690/10700/10710/10720/10730/10740/10750/10760/10770/10780/10790/10800/10810/10820/10830/10840/10850/10860/10870/10880/10890/10900/10910/10920/10930/10940/10950/10960/10970/10980/10990/11000/11010/11020/11030/11040/11050/11060/11070/11080/11090/11100/11110/11120/11130/11140/11150/11160/11170/11180/11190/11200/11210/11220/11230/11240/11250/11260/11270/11280/11290/11300/11310/11320/11330/11340/11350/11360/11370/11380/11390/11400/11410/11420/11430/11440/11450/11460/11470/11480/11490/11500/11510/11520/11530/11540/11550/11560/11570/11580/11590/11600/11610/11620/11630/11640/11650/11660/11670/11680/11690/11700/11710/11720/11730/11740/11750/11760/11770/11780/11790/11800/11810/11820/11830/11840/11850/11860/11870/11880/11890/11900/11910/11920/11930/11940/11950/11960/11970/11980/11990/12000/12010/12020/12030/12040/12050/12060/12070/12080/12090/12100/12110/12120/12130/12140/12150/12160/12170/12180/12190/12200/12210/12220/12230/12240/12250/12260/12270/12280/12290/12300/12310/12320/12330/12340/12350/12360/12370/12380/12390/12400/12410/12420/12430/12440/12450/12460/12470/12480/12490/12500/12510/12520/12530/12540/12550/12560/12570/12580/12590/12600/12610/12620/12630/12640/12650/12660/12670/12680/12690/12700/12710/12720/12730/12740/12750/12760/12770/12780/12790/12800/12810/12820/12830/12840/12850/12860/12870/12880/12890/12900/12910/12920/12930/12940/12950/12960/12970/12980/12990/13000/13010/13020/13030/13040/13050/13060/13070/13080/13090/13100/13110/13120/13130/13140/13150/13160/13170/13180/13190/13200/13210/13220/13230/13240/13250/13260/13270/13280/13290/13300/13310/13320/13330/13340/13350/13360/13370/13380/13390/13400/13410/13420/13430/13440/13450/13460/13470/13480/13490/13500/13510/13520/13530/13540/13550/13560/13570/13580/13590/13600/13610/13620/13630/13640/13650/13660/13670/13680/13690/13700/13710/13720/13730/13740/13750/13760/13770/13780/13790/13800/13810/13820/13830/13840/13850/13860/13870/13880/13890/13900/13910/13920/13930/13940/13950/13960/13970/13980/13990/14000/14010/14020/14030/14040/14050/14060/14070/14080/14090/14100/14110/14120/14130/14140/14150/14160/14170/14180/14190/14200/14210/14220/14230/14240/14250/14260/14270/14280/14290/14300/14310/14320/14330/14340/14350/14360/14370/14380/14390/14400/14410/14420/14430/14440/14450/14460/14470/14480/14490/14500/14510/14520/14530/14540/14550/14560/14570/14580/14590/14600/14610/14620/14630/14640/14650/14660/14670/14680/14690/14700/14710/14720/14730/14740/14750/14760/14770/14780/14790/14800/14810/14820/14830/14840/14850/14860/14870/14880/14890/14900/14910/14920/14930/14940/14950/14960/14970/14980/14990/15000/15010/15020/15030/15040/15050/15060/15070/15080/15090/15100/15110/15120/15130/15140/15150/15160/15170/15180/15190/15200/15210/15220/15230/15240/15250/15260/15270/15280/15290/15300/15310/15320/15330/15340/15350/15360/15370/15380/15390/15400/15410/15420/15430/15440/15450/15460/15470/15480/15490/15500/15510/15520/15530/15540/15550/15560/15570/15580/15590/15600/15610/15620/15630/15640/15650/15660/15670/15680/15690/15700/15710/15720/15730/15740/15750/15760/15770/15780/15790/15800/15810/15820/15830/15840/15850/15860/15870/15880/15890/15900/15910/15920/15930/15940/15950/15960/15970/15980/15990/16000/16010/16020/16030/16040/16050/16060/16070/16080/16090/16100/16110/16120/16130/16140/16150/16160/16170/16180/16190/16200/16210/16220/16230/16240/16250/16260/16270/16280/16290/16300/16310/16320/16330/16340/16350/16360/16370/16380/16390/16400/16410/16420/16430/16440/16450/16460/16470/16480/16490/16500/16510/16520/16530/16540/16550/16560/16570/16580/16590/16600/16610/16620/16630/16640/16650/16660/16670/16680/16690/16700/16710/16720/16730/16740/16750/16760/16770/16780/16790/16800/16810/16820/16830/16840/16850/16860/16870/16880/16890/16900/16910/16920/16930/16940/16950/16960/16970/16980/16990/17000/17010/17020/17030/17040/17050/17060/17070/17080/17090/17100/17110/17120/17130/17140/17150/17160/17170/17180/17190/17200/17210/17220/17230/17240/17250/17260/17270/17280/17290/17300/17310/17320/17330/17340/17350/17360/17370/17380/17390/17400/17410/17420/17430/17440/17450/17460/17470/17480/17490/17500/17510/17520/17530/17540/17550/17560/17570/17580/17590/17600/17610/17620/17630/17640/17650/17660/17670/17680/17690/17700/17710/17720/17730/17740/17750/17760/17770/17780/17790/17800/17810/17820/17830/17840/17850/17860/17870/17880/17890/17900/17910/17920/17930/17940/17950/17960/17970/17980/17990/18000/18010/18020/18030/18040/18050/18060/18070/18080/18090/18100/18110/18120/18130/18140/18150/18160/18170/18180/18190/18200/18210/18220/18230/18240/18250/18260/18270/18280/18290/18300/18310/18320/18330/18340/18350/18360/18370/18380/18390/18400/18410/18420/18430/18440/18450/18460/18470/18480/18490/18500/18510/18520/18530/18540/18550/18560/18570/18580/18590/18600/18610/18620/18630/18640/18650/18660/18670/18680/18690/18700/18710/18720/18730/18740/18750/18760/18770/18780/18790/18800/18810/18820/18830/18840/18850/18860/18870/18880/18890/18900/18910/18920/18930/18940/18950/18960/18970/18980/18990/19000/19010/19020/19030/19040/19050/19060/19070/19080/19090/19100/19110/19120/19130/19140/19150/19160/19170/19180/19190/19200/19210/19220/19230/19240/19250/19260/19270/19280/19290/19300/19310/19320/19330/19340/19350/19360/19370/19380/19390/19400/19410/19420/19430/19440/19450/19460/19470/19480/19490/19500/19510/19520/19530/19540/19550/19560/19570/19580/19590/19600/19610/19620/19630/19640/19650/19660/19670/19680/19690/19700/19710/19720/19730/19740/19750/19760/19770/19780/19790/19800/19810/19820/19830/19840/19850/19860/19870/19880/19890/19900/19910/19920/19930/19940/19950/19960/19970/19980/19990/20000/20010/20020/20030/20040/20050/20060/20070/20080/20090/20100/20110/20120/20130/20140/20150/20160/20170/20180/20190/20200/20210/20220/20230/20240/20250/20260/20270/20280/20290/20300/20310/20320/20330/20340/20350/20360/20370/20380/20390/20400/20410/20420/20430/20440/20450/20460/20470/20480/20490/20500/20510/20520/20530/20540/20550/20560/20570/20580/20590/20600/20610/20620/20630/20640/20650/20660/20670/20680/20690/20700/20710/20720/20730/20740/20750/20760/20770/20780/20790/20800/20810/20820/20830/20840/20850/20860/20870/20880/20890/20900/20910/20920/20930/20940/20950/20960/20970/20980/20990/21000/21010/21020/21030/21040/21050/21060/21070/21080/21090/21100/21110/21120/21130/21140/21150/21160/21170/21180/21190/21200/21210/21220/21230/21240/21250/21260/21270/21280/21290/21300/21310/21320/21330/21340/21350/21360/21370/21380/21390/21400/21410/21420/21430/21440/21450/21460/21470/21480/21490/21500/21510/21520/21530/21540/21550/21560/21570/21580/21590/21600/21610/21620/21630/21640/21650/21660/21670/21680/21690/21700/21710/21720/21730/21740/21750/21760/21770/21780/21790/21800/21810/21820/21830/21840/21850/21860/21870/21880/21890/21900/21910/21920/21930/21940/21950/21960/21970/21980/21990/22000/22010/22020/22030/22040/22050/22060/22070/22080/22090/22100/22110/22120/22130/22140/22150/22160/22170/22180/22190/22200/22210/22220/22230/22240/22250/22260/22270/22280/22290/22300/22310/22320/22330/22340/22350/22360/22370/22380/22390/22400/22410/22420/22430/22440/22450/22460/22470/22480/22490/22500/22510/22520/22530/22540/22550/22560/22570/22580/22590/22600/22610/22620/22630/22640/22650/22660/22670/22680/22690/22700/22710/22720/22730/22740/22750/22760/22770/22780/22790/22800/22810/22820/22830/22840/22850/22860/22870/22880/22890/22900/22910/22920/22930/22940/22950/22960/22970/22980/22990/23000/23010/23020/23030/23040/23050/23060/23070/23080/23090/23100/23110/23120/23130/23140/23150/23160/23170/23180/23190/23200/23210/23220/23230/23240/23250/23260/23270/23280/23290/23300/23310/23320/23330/23340/23350/23360/23370/23380/23390/23400/23410/23420/23430/23440/23450/23460/23470/23480/23490/23500/23510/23520/23530/23540/23550/23560/23570/23580/23590/23600/23610/23620/23630/23640/23650/23660/23670/23680/23690/23700/23710/23720/23730/23740/23750/23760/23770/23780/23790/23800/23810/23820/23830/23840/23850/23860/23870/23880/23890/23900/23910/23920/23930/23940/23950/23960/23970/23980/23990/24000/24010/24020/24030/24040/24050/24060/24070/24080/24090/24100/24110/24120/24130/24140/24150/24160/24170/24180/24190/24200/24210/24220/24230/24240/24250/24260/24270/24280/24290/24300/24310/24320/24330/24340/24350/24360/24370/24380/24390/24400/24410/24420/24430/24440/24450/24460/24470/24480/24490/24500/24510/24520/24530/24540/24550/24560/24570/24580/24590/24600/24610/24620/24630/24640/24650/24660/24670/24680/24690/24700/24710/24720/24730/24740/24750/24760/24770/24780/24790/24800/24810/24820/24830/24840/24850/24860/24870/24880/24890/24900/24910/24920/24930/24940/24950/24960/24970/24980/24990/25000/25010/25020/25030/25040/25050/25060/25070/25080/25090/25100/25110/25120/25130/25140/25150/25160/25170/25180/25190/25200/25210/25220/25230/25240/25250/25260/25270/25280/25290/25300/25310/25320/25330/25340/25350/25360/25370/25380/25390/25400/25410/25420/25430/25440/25450/25460/25470/25480/25490/25500/25510/25520/25530/25540/25550/25560/25570/25580/25590/25600/25610/25620/25630/25640/25650/25660/25670/25680/25690/25700/25710/25720/25730/25740/25750/25760/25770/25780/25790/25800/25810/25820/25830/25840/25850/25860/25870/25880/25890/25900/25910/25920/25930/25940/25950/25960/25970/25980/25990/26000/26010/26020/26030/26040/26050/26060/26070/26080/26090/26100/26110/26120/26130/26140/26150/26160/26170/26180/26190/26200/26210/26220/26230/26240/26250/26260/26270/26280/26290/26300/26310/26320/26330/26340/26350/26360/26370/26380/26390/26400/26410/26420/26430/26440/26450/26460/26470/26480/26490/26500/26510/26520/26530/26540/26550/26560/26570/26580/26590/26600/26610/26620/26630/26640/26650/26660/26670/26680/26690/26700/26710/26720/26730/26740/26750/26760/26770/26780/26790/26800/26810/26820/26830/26840/26850/26860/26870/26880/26890/26900/26910/26920/26930/26940/26950/26960/26970/26980/26990/27000/27010/27020/27030/27040/27050/27060/27070/27080/27090/27100/27110/27120/27130/27140/27150/27160/27170/27180/27190/27200/27210/27220/27230/27240/27250/27260/27270/27280/27290/27300/27310/27320/27330/27340/27350/27360/27370/27380/27390/27400/27410/27420/27430/27440/27450/27460/27470/27480/27490/27500/27510/27520/27530/27540/27550/27560/27570/27580/27590/27600/27610/27620/27630/27640/27650/27660/27670/27680/27690/27700/27710/27720/27730/27740/27750/27760/27770/27780/27790/27800/27810/27820/27830/27840/27850/27860/27870/27880/27890/27900/27910/27920/27930/27940/27950/27960/27970/27980/27990/28000/28010/28020/28030/28040/28050/28060/28070/28080/28090/28100/28110/28120/28130/28140/28150/28160/28170/28180/28190/28200/28210/28220/28230/28240/28250/28260/28270/28280/28290/28300/28310/28320/28330/28340/28350/28360/28370/28380/28390/28400/28410/28420/28430/28440/28450/28460/28470/28480/28490/28500/28510/28520/28530/28540/28550/28560/28570/28580/28590/28600/28610/28620/28630/28640/28650/28660/28670/28680/28690/28700/28710/28720/28730/28740/28750/28760/28770/28780/28790/28800/28810/28820/28830/28840/28850/28860/28870/28880/28890/28900/28910/28920/28930/28940/28950/28960/28970/28980/28990/29000														

TOZC	and	DOG	received broken. pk.

4036 Youngfield St.
Wheat Ridge, Colorado 80090
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

FAX # (303) 831-8200 FAX RESULTS Y / N (800) 845-7400

Sampler Name: Bob Nager
(signature)
(print) BOB NAGER

PRINT
Please

all information:

CLIENT
SAMPLE

SAMPLE IDENTIFICATION	DATE SAMPLE
-----------------------	-------------

LF6 MPO	11/14/96	0730	13
LF6 MPP	11/14/96	0720	13
W78	11/14/96	1110	13
W21	11/14/96	1320	13
W30	11/14/96	1515	12
W2	11/14/96	1130	7
LF6 MPP	11/14/96	1645	12
TRIP BLANK	11/14/96		1

[illegible]

TOZC	and	DOG	received broken. pk.

4036 Youngfield St.
Wheat Ridge, Colorado 80090
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

FAX # (303) 831-8200 FAX RESULTS Y / N (800) 845-7400

Sampler Name: Bob Nager
(signature)
(print) BOB NAGER

PRINT
Please

all information:

CLIENT
SAMPLE

SAMPLE IDENTIFICATION	DATE SAMPLE
-----------------------	-------------

LF6 MPO	11/14/96	0730	13
LF6 MPP	11/14/96	0720	13
W78	11/14/96	1110	13
W21	11/14/96	1320	13
W30	11/14/96	1515	12
W2	11/14/96	1130	7
LF6 MPP	11/14/96	1645	12
TRIP BLANK	11/14/96		1

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB2111896 Client Project Number : 729691.32010
Date Prepared : 11/18/96 Lab Work Order : 96-4047
Dilution Factor : 1.0 Matrix : WATER
Lab File Number : TVB21118003

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/18/96	U	0.1	mg/L
Benzene	71-43-2	11/18/96	U	0.4	ug/L
Toluene	108-88-3	11/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/18/96	U	0.5	ug/L
FID Surrogate Recovery:		92%		70%-126%	(Limits)
Surrogate Recovery:		97%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Bliska
Analyst

K. Holliman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB2111996 Client Project Number : 729691.32010
Date Prepared : 11/19/96 Lab Work Order : 96-4047
Dilution Factor : 1.0 Matrix : WATER
Lab File Number : TVB21118037


Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/19/96	U	0.1	mg/L
Benzene	71-43-2	11/19/96	U	0.4	ug/L
Toluene	108-88-3	11/19/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/19/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/19/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/19/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/19/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/19/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/19/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/19/96	U	0.5	ug/L
FID Surrogate Recovery:		96%		70%-126%	(Lin
PID Surrogate Recovery:		99%		76%-127%	(Li

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6 MPO Client Project Number : 729691.32010
Lab Sample Number : 96-4047-01 Lab Work Order : 96-4047
Date Sampled : 11/14/96 Matrix : WATER
Date Received : 11/15/96 Lab File Number(s) : TVB21118019
Date Prepared : 11/18/96 Method Blank : MB2111896
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/18/96	U	0.1	mg/L
Benzene	71-43-2	11/18/96	2.0	0.4	ug/L
Toluene	108-88-3	11/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/18/96	4.1	0.4	ug/L
Ethyl Benzene	100-41-4	11/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/18/96	0.6	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/18/96	0.6	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/18/96	U	0.5	ug/L
Surrogate Recovery: 97% 70%-126% (Limits)					
Surrogate Recovery: 97% 76%-127% (Limits)					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: LF6 MPP	Client Project Number	: 729691.32010
Lab Sample Number	: 96-4047-02	Lab Work Order	: 96-4047
Date Sampled	: 11/14/96	Matrix	: WATER
Date Received	: 11/15/96	Lab File Number(s)	: TVB21118022
Date Prepared	: 11/18/96	Method Blank	: MB2111896
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/18/96	U	0.1	mg/L
Benzene	71-43-2	11/18/96	3.4	0.4	ug/L
Toluene	108-88-3	11/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/18/96	5.9	0.4	ug/L
Ethyl Benzene	100-41-4	11/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/18/96	U	0.5	ug/L
FID Surrogate Recovery:		99%		70%-126%	(L)
PID Surrogate Recovery:		95%		76%-127%	(L)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
 U = Compound analyzed for, but not detected.
 B = Compound also found in the blank.
 J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
 RL = Reporting Limit.
 NA = Not Available/Not Applicable.
 PID = Photoionization detector.
 FID = Flame ionization detector.
 TVH = Total Volatile Hydrocarbons.

M. Decia
Analyst

K. Hallman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : W78 Client Project Number : 729691.32010
Lab Sample Number : 96-4047-03 Lab Work Order : 96-4047
Date Sampled : 11/14/96 Matrix : WATER
Date Received : 11/15/96 Lab File Number(s) : TVB21118025
Date Prepared : 11/18/96 Method Blank : MB2111896
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

1

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/18/96	U	0.1	mg/L
Benzene	71-43-2	11/18/96	U	0.4	ug/L
Toluene	108-88-3	11/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/18/96	U	0.5	ug/L
Surrogate Recovery: 101% 70%-126% (Limits)					
Surrogate Recovery: 96% 76%-127% (Limits)					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : W21 Client Project Number : 729691.32010
Lab Sample Number : 96-4047-04 Lab Work Order : 96-4047
Date Sampled : 11/14/96 Matrix : WATER
Date Received : 11/15/96 Lab File Number(s) : TVB21118026
Date Prepared : 11/18/96 Method Blank : MB2111896
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/18/96	U	0.1	mg/L
Benzene	71-43-2	11/18/96	3.6	0.4	ug/L
Toluene	108-88-3	11/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/18/96	20	0.4	ug/L
Ethyl Benzene	100-41-4	11/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/18/96	0.5	0.5	ug/L
FID Surrogate Recovery:		102%		70%-126%	(Limit)
PID Surrogate Recovery:		96%		76%-127%	(Limit)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blaha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : W20 Client Project Number : 729691.32010
Lab Sample Number : 96-4047-05 Lab Work Order : 96-4047
Date Sampled : 11/14/96 Matrix : WATER
Date Received : 11/15/96 Lab File Number(s) : TVB21118027
Date Prepared : 11/18/96 Method Blank : MB2111896
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/19/96	U	0.1	mg/L
Benzene	71-43-2	11/19/96	U	0.4	ug/L
Toluene	108-88-3	11/19/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/19/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/19/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/19/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/19/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/19/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/19/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/19/96	U	0.5	ug/L
Surrogate Recovery:		93%		70%-126%	(Limits)
Surrogate Recovery:		96%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : W2 Client Project Number : 729631.32010
Lab Sample Number : 96-4047-06 Lab Work Order : 96-4047
Date Sampled : 11/14/96 Matrix : WATER
Date Received : 11/15/96 Lab File Number(s) : TVB21118028
Date Prepared : 11/18/96 Method Blank : MB2111896
FID Dilution Factor : 1.0
PID Dilution Factor : NA

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/19/96	U	0.1	mg/L
Benzene	71-43-2	NA	NA	NA	NA
Toluene	108-88-3	NA	NA	NA	NA
Chlorobenzene	108-90-7	NA	NA	NA	NA
Ethyl Benzene	100-41-4	NA	NA	NA	NA
Total Xylenes (m,p,o)	1330-20-7	NA	NA	NA	NA
1,3,5-Trimethylbenzene	108-67-8	NA	NA	NA	NA
1,2,4-Trimethylbenzene	95-63-6	NA	NA	NA	NA
1,2,3-Trimethylbenzene	526-73-8	NA	NA	NA	NA
1,2,3,4-Tetramethylbenzene	488-23-3	NA	NA	NA	NA
FID Surrogate Recovery: 97% 70%-126% (Line)					
PID Surrogate Recovery: NA 76%-127% (Line)					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6 MPQ Client Project Number : 729691.32010
Lab Sample Number : 96-4047-07 Lab Work Order : 96-4047
Date Sampled : 11/14/96 Matrix : WATER
Date Received : 11/15/96 Lab File Number(s) : TVB21118031
Date Prepared : 11/18/96 Method Blank : MB2111896
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	11/19/96	U	0.1	mg/L
Benzene	71-43-2	11/19/96	U	0.4	ug/L
Toluene	108-88-3	11/19/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/19/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/19/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/19/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/19/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/19/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/19/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/19/96	U	0.5	ug/L
Surrogate Recovery: 100% 70%-126% (Limits)					
PID Surrogate Recovery: 96% 76%-127% (Limits)					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : TRIP BLANK-5 Client Project Number : 729691.32010
Lab Sample Number : 96-4047-08 Lab Work Order : 96-4047
Date Sampled : NA Matrix : WATER
Date Received : 11/15/96 Lab File Number(s) : TVB21118035
Date Prepared : 11/18/96 Method Blank : MB2111896
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/19/96	U	0.1	mg/L
Benzene	71-43-2	11/19/96	U	0.4	ug/L
Toluene	108-88-3	11/19/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/19/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/19/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/19/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/19/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/19/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/19/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/19/96	U	0.5	ug
FID Surrogate Recovery:		92%		70%-126%	(Limits)
PID Surrogate Recovery:		95%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

**TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report**

Client Sample No.	: LF6 MPO	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4047-01	Lab Work Order	: 96-4047
Date Sampled	: 11/14/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 11/15/96	Matrix	: WATER
Date Prepared	: 11/18/96	Lab File Number(s)	: TVB2118020,21
Date Analyzed	: 11/18/96	Method Blank	: MB211896
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#)
					Limits
Gasoline	2.00	0.00	2.16	107.8%	60 - 128
Surrogate **	---	---	---	118%	70 - 126

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#)	
					Limits	
Gasoline	2.00	2.20	110.1%	2.1	44.1	60 - 128
Surrogate **	---	---	117%	NA	NA	70 - 126

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:

NA = Not analyzed/not applicable.

* = Values outside of QC limits.

** = 1,2,4-Trichlorobenzene

= Limits established 10/1/96, MAB

Comments: _____

M. Black
Analyst

K. Holliman
Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: W78	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4047-03	Lab Work Order	: 96-4047
Date Sampled	: 11/14/96	EPA Method No.	: 602/8020
Date Received	: 11/15/96	Matrix	: WATER
Date Prepared	: 11/19/96	Lab File Number(s)	: TVB21118038,39
Date Analyzed	: 11/19/96	Method Blank	: MB2111996
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L)		Comments
			MS	MSD	
Benzene	20.0	0.0	20.1	21.4	
Toluene	20.0	0.0	19.6	20.9	
Chlorobenzene	20.0	0.0	19.6	20.8	
Ethylbenzene	20.0	0.0	19.6	20.9	
m,p-Xylene	20.0	0.0	19.6	20.9	
o-Xylene	20.0	0.0	19.6	20.7	
1,3,5-TMB	20.0	0.0	19.4	20.5	
1,2,4-TMB	20.0	0.0	19.1	20.2	
1,2,3-TMB	20.0	0.0	19.9	20.9	
1,2,3,4-TeMB	20.0	0.0	20.4	21.6	
Surrogate	100.0	96%	102%	105%	% RECOVERY

Compound	MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits	
				RPD	%REC
Benzene	100.5	107.0	6.3	17	61 - 129
Toluene	98.0	104.5	6.4	18	61 - 127
Chlorobenzene	98.0	104.0	5.9	16	68 - 122
Ethylbenzene	98.0	104.5	6.4	18	63 - 126
m,p-Xylene	98.0	104.5	6.4	18	60 - 130
o-Xylene	98.0	103.5	5.5	18	62 - 128
1,3,5-TMB	97.0	102.5	5.5	18	69 - 117
1,2,4-TMB	95.5	101.0	5.6	23	69 - 119
1,2,3-TMB	99.5	104.5	4.9	16	71 - 118
1,2,3,4-TeMB	102.0	108.0	5.7	27	67 - 125
Surrogate	102.0	105.0	NA	NA	76 - 127

= Limits established 10/15/96, KSH

* = Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments: _____

Analyst

M. Blocha

Approved

K. Hollman

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: <u>LCS2111896-GAS</u>	Matrix	: <u>WATER</u>
Date Prepared	: <u>11/18/96</u>	Method Numbers	: <u>EPA 5030/8015 Modified</u>
Date Analyzed	: <u>11/18/96</u>	Instrument Name	: <u>TVHBTEX2</u>
Lab File Number(s)	: <u>TVB21118013</u>		

<u>Compound Name</u>	<u>Theoretical Concentration (mg/L)</u>	<u>LCS Concentration (mg/L)</u>	<u>LCS % Recovery</u>	<u>QC Limit % Recovery</u>
Gasoline	2.00	2.32	115.9	81 - 128

Surrogate Recovery:	125%	70 - 126
---------------------	------	----------

QUALIFIERS

B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA = Not Available/Not Applicable.
** = Limits established 10/1/96 for TVHBTEX2. MAB

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St.
Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number : LCS2111896-BTEX
Date Extracted/Prepared : 11/18/96
Date Analyzed : 11/18/96
Spike Amount (ug/L) : 20.0

Dilution Factor : 1.00
Method : 602/8020
Matrix : Water
Lab File No. : TVB221118014

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	20.6	103.0	75 - 116
Toluene	108-88-3	20.0	100.0	75 - 118
Chlorobenzene	108-90-7	18.2	91.0	73 - 115
Ethyl Benzene	100-41-4	19.7	98.5	80 - 122
m,p-Xylene	108-38-3	38.1	95.3	76 - 120
o-Xylene	106-42-3			
	95-47-6	20.0	100.0	76 - 117
MTBE	1634-04-4	20.5	102.5	75 - 115
1,3,5-Trimethylbenzene	108-67-8	19.6	98.0	64 - 118
1,2,4-Trimethylbenzene	95-63-6	18.1	90.5	75 - 111
1,2,3-Trimethylbenzene	526-73-8	22.6	113.0	82 - 127
1,2,3,4-Tetramethylbenzene	488-23-3	20.6	103.0	72 - 131
Surrogate Recovery:		100%		76 - 127

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:

E = Extrapolated value. Value exceeds that of the calibration range.

U = Compound analyzed for, but not detected.

B = Compound found in blank and sample. Compare blank and sample data.

NA = Not available/Not analyzed.

** = Limits established 10/1/96 for TVHBTEX2. MAB

Analyst

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 8010 Chlorinated VOC's Method Blank Report

Method Blank : RB112196 Client Project No. : 729691.32010
Date Prepared : 11/21/96 Lab Project No. : 96-4047
Date Analyzed : 11/21/96 Lab File No. : HALL1121\004F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,4-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 81% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4047.XLS; 11/26/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Method Blank Report

Method Blank : RB112596 Client Project No. : 729691.32010
Date Prepared : 11/25/96 Lab Project No. : 96-4047
Date Analyzed : 11/25/96 Lab File No. : HALL1125\004F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 85% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4047.XLS; 11/26/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : LF6 MPO Client Project No. : 729691.32010
Lab Sample No. : 96-4047-01 Lab Project No. : 96-4047
Date Sampled : 11/14/96 Matrix : Water
Date Received : 11/15/96 Lab File No. : HALL1121\024F0101
Date Prepared : 11/21/96 Method Blank : RB112196
Date Analyzed : 11/21/96 Dilution Factor : 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	8	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	1	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	0.44 J	0.4
cis-1,2-Dichloroethene	156-59-4	15	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	0.68 J	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	1.6 J	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 86% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4047.XLS; 11/28/98

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6 MPP	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4047-02	Lab Project No.	: 96-4047
Date Sampled	: 11/14/96	Matrix	: Water
Date Received	: 11/15/96	Lab File No.	: HALL1121\025F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/22/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	9	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	0.49 J	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	7.5	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	2.3	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	0.74 J	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 84% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4047.XLS; 11/26/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : W78 Client Project No. : 729691.32010
Lab Sample No. : 96-4047-03 Lab Project No. : 96-4047
Date Sampled : 11/14/96 Matrix : Water
Date Received : 11/15/96 Lab File No. : HALL1121\026F0101
Date Prepared : 11/21/96 Method Blank : RB112196
Date Analyzed : 11/22/96 Dilution Factor : 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
Chlorotoluene	106-49-8	U	0.4
3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 81% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4047.XLS; 11/28/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: W21	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4047-04	Lab Project No.	: 96-4047
Date Sampled	: 11/14/96	Matrix	: Water
Date Received	: 11/15/96	Lab File No.	: HALL1121\027F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/22/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	10	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	0.43 J	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	0.81 J	0.4
cis-1,2-Dichloroethene	156-59-4	14	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	7.4	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	13	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	1.9	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 86% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4047.XLS; 11/26/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: W20	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4047-05	Lab Project No.	: 96-4047
Date Sampled	: 11/14/96	Matrix	: Water
Date Received	: 11/15/96	Lab File No.	: HALL1121\028F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/22/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
Chlorotoluene	95-49-8	U	0.4
Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 77% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4047.XLS; 11/28/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: W2	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4047-06	Lab Project No.	: 96-4047
Date Sampled	: 11/14/96	Matrix	: Water
Date Received	: 11/15/96	Lab File No.	: HALL1125\006F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 88% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4047.XLS; 11/26/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6 MPQ	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4047-07	Lab Project No.	: 96-4047
Date Sampled	: 11/14/96	Matrix	: Water
Date Received	: 11/15/96	Lab File No.	: HALL1125\007F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 90% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4047.XLS; 11/26/96

Method 601/8010 Chlorinated VOC's Sample Report

Client Project No. : 729691.32010
Lab Project No. : 96-4047
Matrix : Water
Lab File No. : HALL1125\008F0101
Method Blank : RB112596
Dilution Factor : 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

QUALIFIERS:

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4047.XLS; 11/26/96

Method 8010 Control Samples

Date Performed: 11/21/96

Reference Standard: V832

Analyte	M	Method Blank	Sample	Sample Spike	Spike Dup.	Control Spike	Spike Amt	RPD	Spike Recoveries			QC Recovery Range		
									Sample	Dup	# Control	% L - % H	Low	High
Vinyl Chloride	W			16.242	16.939	18.000	20.0	4.2	81%	85%	90%	28 - 163	5.60	32.60
Chloroethane	*			18.077	18.149	18.375	20.0	0.4	90%	91%	92%	46 - 137	9.20	27.40
1,1-Dichloroethene	*			18.412	18.596	18.944	20.0	1.0	92%	93%	95%	28 - 167	5.60	33.40
Dichloromethane	*			16.549	17.379	17.787	20.0	4.9	83%	87%	89%	25 - 162	5.00	32.40
trans-1,2-Dichloroethene	*			22.277	22.808	22.588	20.0	2.4	111%	114%	113%	38 - 155	7.60	31.00
1,1-Dichloroethane	*			19.461	19.864	20.012	20.0	2.0	97%	99%	100%	47 - 132	9.40	28.40
cis-1,2-Dichloroethene	*			19.861	20.366	20.446	20.0	2.5	99%	102%	102%	-	-	-
1,1,1-Trichloroethane	*			19.811	20.244	20.065	20.0	2.2	99%	101%	100%	41 - 138	8.20	27.60
Carbon Tetrachloride	*			20.406	20.554	20.471	20.0	0.7	102%	103%	102%	43 - 143	8.60	28.60
Trichloroethene	W			20.741	21.314	20.734	20.0	2.7	104%	107%	104%	35 - 146	7.00	29.20
1,1,2-Trichloroethane	W			19.987	18.51	19.862	20.0	7.7	100%	93%	99%	39 - 136	7.80	27.20
Tetrachloroethene	*			19.678	19.422	19.850	20.0	1.3	98%	97%	99%	26 - 162	5.20	32.40
1,1,1,2-Tetrachloroethane	*			18.214	18.494	18.133	20.0	1.5	91%	92%	91%	-	-	-
Chlorobenzene	*			18.858	20.447	18.803	20.0	8.1	94%	102%	94%	1 - 150	0.16	30.00
1,1,2,2-Tetrachloroethane	*			18.777	17.532	21.414	20.0	6.9	94%	88%	107%	8 - 184	1.60	36.80
2-Chlorotoluene	*			18.101	18.118	19.399	20.0	0.1	91%	91%	97%	-	-	-
4-Chlorotoluene	*			17.338	16.991	18.771	20.0	2.0	87%	85%	94%	-	-	-
1,3-Dichlorobenzene	*			16.993	17.568	17.339	20.0	3.3	85%	88%	87%	7 - 187	1.40	37.40
1,2-Dichlorobenzene	*			16.648	15.984	16.729	20.0	4.1	83%	80%	84%	0 - 208	0.00	41.60

M = Applicable matrices. (* = Soil and Water. W = Water only.)

= Marks a spike recovery out of limits.

If recovery is outside method limit, marked with ***.

If recovery is outside a guideline, marked with ~.

If the sample spike recovery is outside the limit and the control spike is outside the limit also, the control is marked with **** or ~.

Notes on recovery limits:

All spiked analytes must be detected even if low limit is 0.

For analytes not listed in the method, recovery limits of 50-150% will be used as guidelines until limits can be established.

Corrective Actions:

Unacceptable sample spike recovery requires acceptable control spike recovery. If both recoveries are outside limits, corrective action must be taken. One recovery outside limits and the other acceptable, is a warning. Repeated failure requires corrective action. Recoveries outside guidelines should be compared to historical data available to determine if corrective action is required.

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021


Methane Report Form
Method Blank Report

Method Blank Number	: GB112196	Client Project No.	: 729691.32010
Date Extracted/Prepared	: 11/21/96	Lab Work Order	: 96-4047
Date Analyzed	: 11/21/96	Dilution Factor	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS1121002

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number : LF6 MPO Client Project No. : 729691.32010
Lab Sample Number : 96-4047-01 Lab Work Order : 96-4047
Date Sampled : 11/14/96 Dilution Factor : 50.00
Date Received : 11/15/96 Method : RSKSOP-175M
Date Extracted/Prepared : 11/21/96 Matrix : Water
Date Analyzed : 11/21/96 Lab File No. : GAS1121016


Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	1.8	0.1

Temperature	: 73.8 F	Saturation Meth	: 0.443690383
Volume Injected	: 0.01 ml	Concentration	
Volume of Sample	: 43 ml	Concentration Meth	: 1.393251313
Head space created	: 4 ml	in Head Space	
Methane Area	: 206.356 ug		

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
'A' = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6 MPP	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4047-02	Lab Work Order	: 96-4047
Date Sampled	: 11/14/96	Dilution Factor	: 100.00
Date Received	: 11/15/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/21/96	Matrix	: Water
Date Analyzed	: 11/21/96	Lab File No.	: GAS1121017


Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	2.7	0.2

Temperature	: 74.4 F	Saturation	Meth	0.6408
Amount Injected	: 0.005 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	2.0100
Head space created	: 4 ml	in Head Space		
Methane Area	: 149.023 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: W78	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4047-03	Lab Work Order	: 96-4047
Date Sampled	: 11/14/96	Dilution Factor	: 1.00
Date Received	: 11/15/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/21/96	Matrix	: Water
Date Analyzed	: 11/21/96	Lab File No.	: GAS1121018

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.021	0.002

Temperature	: 74.1 F	Saturation Meth	: 0.004974606
Amount Injected	: 0.5 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	: 0.015612191
Head space created	: 4 ml	in Head Space	
Methane Area	: 115.682 ug		

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.


U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

A = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: W21	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4047-04	Lab Work Order	: 96-4047
Date Sampled	: 11/14/96	Dilution Factor	: 50.00
Date Received	: 11/15/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/21/96	Matrix	: Water
Date Analyzed	: 11/21/96	Lab File No.	: GAS1121019

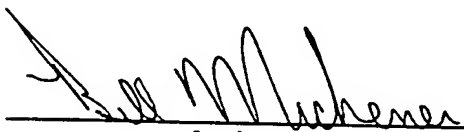
Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	2.7	0.1

Temperature	: 74.3 F	Saturation Meth	: 0.65
Amount Injected	: 0.01 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	: 2.066516C
Head space created	: 4 ml	in Head Space	
Methane Area	: 306.361 ug		

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: W20	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4047-05	Lab Work Order	: 96-4047
Date Sampled	: 11/14/96	Dilution Factor	: 1.00
Date Received	: 11/15/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/21/96	Matrix	: Water
Date Analyzed	: 11/21/96	Lab File No.	: GAS1121020


Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 75.2 F	Saturation	Meth	0
Amount Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0
Head space created	: 4 ml	in Head Space		
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
A = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6 MPQ	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4047-07	Lab Work Order	: 96-4047
Date Sampled	: 11/14/96	Dilution Factor	: 1.00
Date Received	: 11/15/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/21/96	Matrix	: Water
Date Analyzed	: 11/21/96	Lab File No.	: GAS1121021

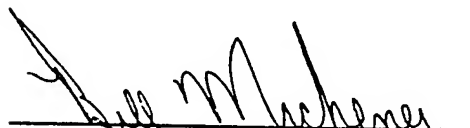
Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 75.4 F	Saturation	Meth
Amount Injected	: 0.5 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration	Meth
Head space created	: 4 ml	in Head Space	
Methane Area	: 0 ug		

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane LCS Report Form

LCS No. : LCS112196 EPA Method No. : RSKSOP-175M
Date Prepared : 11/21/96 Matrix : Water
Date Analyzed : 11/21/96 Method Blank : GB112196
E.A. LCS Source No. : 1886 Lab File No. : GAS1121006

Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	409	82	64-90

Spike Recovery: 0 out of (1) outside limits.

Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes

* = Values outside of QC limits.

NA = Not analyzed/not available.


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/14/96
Date Received : 11/15/96
Date Prepared : 11/15/96
Date Analyzed : 11/15/96

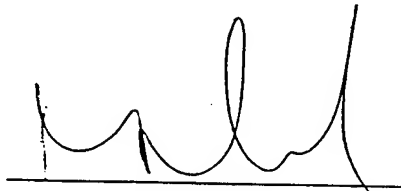
Client Project ID. : 72969.32010
Lab Project Number : 96-4047
Method : EPA 300.0
Detection Limit : 0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride mg/L	Dilution Factor
96-4047-01	LF6 MPO	Water	177	10
96-4047-02	LF6 MPP	Water	44.2	10
96-4047-03	W78	Water	17.5	1
96-4047-03 Duplicate	W78 Duplicate	Water	17.0	1
96-4047-04	W21	Water	54.1	10
96-4047-05	W20	Water	6.7	1
96-4047-07	LF6 MPQ	Water	70.7	10
Method Blank	(11/15/96)	Water	<0.25	1

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-4047-03	W78 Matrix Spike	10.0	17.5	27.9	104
96-4047-03	W78 Matrix Spike Dup	10.0	17.5	27.7	102
MS/MSD RPD					1.9


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/14/96
Date Received : 11/15/96
Date Prepared : 11/15/96
Date Analyzed : 11/15/96

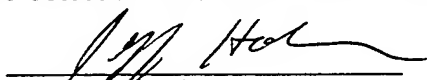
Client Project ID. : 72969.32010
Lab Project Number : 96-4047
Method : EPA 300.0
Detection Limit : 0.076 mg/L

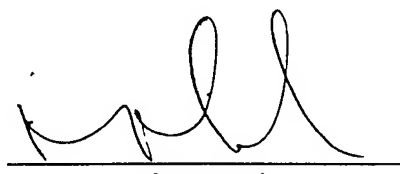
Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N mg/L	Dilution Factor
96-4047-01	LF6 MPO	Water	<0.76**	10
96-4047-02	LF6 MPP	Water	<0.076	1
96-4047-03	W78	Water	<0.076	1
96-4047-03 Duplicate	W78 Duplicate	Water	<0.076	1
96-4047-04	W21	Water	<0.076	1
96-4047-05	W20	Water	<0.076	1
96-4047-07	LF6 MPQ	Water	<0.076	1
Method Blank	(11/15/96)	Water	<0.076	1

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-4047-03	W78 Matrix Spike	10.0	<0.25	9.7	97
96-4047-03	W78 Matrix Spike Dup	10.0	<0.25	9.5	95
MS/MSD	RPD				1.5

* = Quality assurance results reported as Nitrite (NO₂).
** = Raised detection limit due to matrix interference.


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/14/96
Date Received : 11/15/96
Date Prepared : 11/15/96
Date Analyzed : 11/15/96

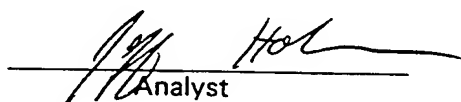
Client Project ID. : 72969.32010
Lab Project Number : 96-4047
Method : EPA 300.0
Detection Limit : 0.056 mg/L


<u>Evergreen Sample #</u>	<u>Client Sample ID.</u>	<u>Matrix</u>	<u>Nitrate-N mg/L</u>	<u>Dilution Factor</u>
96-4047-01	LF6 MPO	Water	0.35	1
96-4047-02	LF6 MPP	Water	0.073	1
96-4047-03	W78	Water	<0.056	1
96-4047-03 Duplicate	W78 Duplicate	Water	<0.056	1
96-4047-04	W21	Water	0.38	1
96-4047-05	W20	Water	2.5	1
96-4047-07	LF6 MPQ	Water	1.5	1
Method Blank	(11/15/96)	Water	<0.056	1

Quality Assurance *

		<u>Spike Amount (mg/L)</u>	<u>Sample Result (mg/L)</u>	<u>Spike Result (mg/L)</u>	<u>% Recovery</u>
96-4047-03	W78 Matrix Spike	10.0	<0.25	9.5	95
96-4047-03	W78 Matrix Spike Dup	10.0	<0.25	9.4	94
MS/MSD RPD					1.7

* = Quality assurance results reported as Nitrate (NO₃).


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/14/96
Date Received : 11/15/96
Date Prepared : 11/15/96
Date Analyzed : 11/15/96

Client Project ID. : 72969.32010
Lab Project Number : 96-4047
Method : EPA 300.0
Detection Limit : 0.25 mg/L

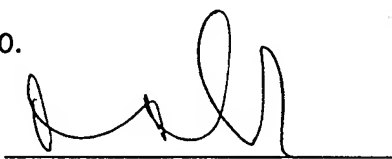
Evergreen Sample #	Client Sample ID.	Matrix	Sulfate mg/L	Dilution Factor
96-4047-01	LF6 MPO	Water	6.0	1
96-4047-02	LF6 MPP	Water	2.2	1
96-4047-03	W78	Water	50.6	10
96-4047-03 Duplicate	W78 Duplicate	Water	50.7	10
96-4047-04	W21	Water	<0.25	1
96-4047-05	W20	Water	0.41	1
96-4047-07	LF6 MPQ	Water	0.34	1
Method Blank	(11/15/96)	Water	<0.25	1

Quality Assurance*

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-4047-03	W78 Matrix Spike	10.0	5.1	14.6	96
96-4047-03	W78 Matrix Spike Dup	10.0	5.1	14.5	94
MS/MSD	RPD				1.3

* = Quality assurance based on a sample dilution factor of 10.


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Total Organic Carbon

Date Sampled : 11/14/96
Date Received : 11/15/96
Date Prepared : 11/25/96
Date Analyzed : 11/25/96

Client Project ID. : 729691.32010
Lab Project Number : 96-4047
Method : EPA 415.1
Detection Limit : 1.0 mg C/L

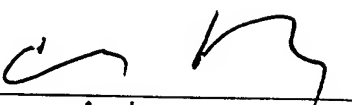
Evergreen Sample #	Client Sample ID.	Matrix	TOC mg C/L	Dilution Factor
96-4047-01	LF6 MPO	Water	34.7	1
96-4047-01 Duplicate	LF6 MPO Duplicate	Water	34.6	1
96-4047-02	LF6 MPP	Water	3.4	1
96-4047-03	W 78	Water	2.1	1
96-4047-04	W 21	Water	4.6	1


Method Blank (11/25/96) <1.0

Quality Assurance

		Spike Amount (mgC/L)	Sample Result (mgC/L)	Spike Result (mgC/L)	% Recovery
96-4047-01	LF6 MPO Matrix Spike	10.0	34.7	45.6	109
96-4047-01	LF6 MPO Matrix Spike Dup	10.0	34.7	44.7	100

MS/MSD RPD 8.5


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Analysis Report

Date Sampled : 11/14/96
Date Received : 11/15/96
Date Prepared : 11/18/96
Date Analyzed : 11/18/96

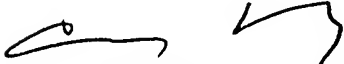
Client Project ID. : 72969.32010
Lab Project Number : 96-4047
Method : EPA 310.1
Detection Limit : 5.0 mg CaCO₃/L

<u>Evergreen Sample #</u>	<u>Client Sample ID.</u>	<u>Matrix</u>	<u>Total Alkalinity (mg CaCO₃/L)</u>	<u>Dilution Factor</u>
96-4047-01	LF6 MPO	Water	19.5	1
96-4047-02	LF6 MPP	Water	10.0	1
96-4047-03	W78	Water	<5.0	1
96-4047-04	W21	Water	<5.0	1
96-4047-05	W20	Water	<5.0	1
96-4047-07	LF6 MPQ	Water	21.1	1
96-4047-07 Duplicate	LF6 MPQ Duplicate	Water	21.2	1
Method Blank	(11/18/96)		<5.0	


Quality Assurance

<u>Reference</u>	<u>True Value</u> (mgCaCO ₃ /L)	<u>Result</u> (mgCaCO ₃ /L)	<u>% Recovery</u>
ERA Minerals	120	114	95

Lot # 0725-96-11



Analyst



Approved

WORK ORDER Summary

Reported by: Dave Moutoux

Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.32010

Phone: (303) 831-8100

FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-4058-01A	LF06-MPF-(4'-8')	% Moisture for dry weight calculation		Soil	2	15-Nov-96	16-Nov-96	03-Dec-96	13-Dec-96
96-4058-02A	LF06-MPF-(8'-10')	% Moisture for dry weight calculation						03-Dec-96	13-Dec-96
96-4058-03H	W79	Anions by IC Cl,NO2,NO3,SO4		Water	D5			03-Dec-96	17-Nov-96
96-4058-04H	W82	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	17-Nov-96
96-4058-05H	LF6-MPH	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	17-Nov-96
96-4058-06H	LF6-MPL	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	17-Nov-96
96-4058-07H	W18	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	17-Nov-96
96-4058-08H	LF6-MPK	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	17-Nov-96
96-4058-09H	LF6-MPI	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	17-Nov-96
96-4058-01A	LF06-MPF-(4'-8')	BTEX (Parsons List)		Soil	2			03-Dec-96	29-Nov-96
96-4058-02A	LF06-MPF-(8'-10')	BTEX (Parsons List)						03-Dec-96	29-Nov-96
96-4058-03A	W79	BTEX (Parsons List)		Water				03-Dec-96	29-Nov-96
96-4058-04A	W82	BTEX (Parsons List)						03-Dec-96	29-Nov-96
96-4058-05A	LF6-MPH	BTEX (Parsons List)						03-Dec-96	29-Nov-96
96-4058-06A	LF6-MPL	BTEX (Parsons List)						03-Dec-96	29-Nov-96
96-4058-07A	W18	BTEX (Parsons List)						03-Dec-96	29-Nov-96
96-4058-08A	LF6-MPK	BTEX (Parsons List)						03-Dec-96	29-Nov-96
96-4058-09A	LF6-MPI	BTEX (Parsons List)						03-Dec-96	29-Nov-96

= Special list. See sample comments or test information.

HT = Holding Time expiration date.

Page 1 of 3

= Special list. See sample comments or test information.

HT = Holding Time expiration date.

Page 2 of 3

11/11/96

Evergreen Analytical, Inc.

96-4058

WORK ORDER Summary

18-Nov-96

Report To: Dave Moutoux

Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.32010

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-4058-04A	W82	TVH (Gasoline)		Water	2	15-Nov-96	16-Nov-96	03-Dec-96	29-Nov-96
96-4058-05A	LF6-MPH	TVH (Gasoline)						03-Dec-96	29-Nov-96
96-4058-06A	LF6-MPL	TVH (Gasoline)						03-Dec-96	29-Nov-96
96-4058-07A	W18	TVH (Gasoline)						03-Dec-96	29-Nov-96
96-4058-08A	LF6-MPK	TVH (Gasoline)						03-Dec-96	29-Nov-96
96-4058-09A	LF6-MPI	TVH (Gasoline)						03-Dec-96	29-Nov-96
96-4058-10A	Trip Blank	TVH (Gasoline)			9			03-Dec-96	29-Nov-96

CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

Evergreen Analytical Inc.

4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

COMPANY PERSONS ES
ADDRESS 1700 Broadway St. #100
CITY DENVER STATE CO ZIP 80290
PHONE# 303-413-8100 FAX # 303-831-8208

CLIENT CONTACT (print) Jenny Hatfield
CLIENT PROJ. I.D. 729691.32010
EAL QUOTE # P.O.# 729691.32010
TURNAROUND REQUIRED* ☒ STD (2 wks) ☐ UST

Sampler Name:

(signature) Rob Nagel
(print) Bruce Henry / Rob Nagel

*expedited turnaround subject to additional fee

PRINT

Please
all information:

CLIENT
SAMPLE
IDENTIFICATION

DATE
SAMPLED

TIME

LF6-MPF-(4-8)	11/15/96	1300	2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
---------------	----------	------	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Analyse Trip Blank for 8010, 8020/8050 per Jenny Hatfield 11/11/96

Relinquished by: (Signature) Rob Nagel Date/Time 11/15/96 1830
Received by: (Signature) Steve Wynn Date/Time 11/16/96 0845
Relinquished by: (Signature) _____ Date/Time _____
Received by: (Signature) _____ Date/Time _____

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB11111996 Client Project Number : 729691.32010
Date Prepared : 11/19/96 Lab Work Order : 96-4058
Dilution Factor : 1.0 Matrix : Water
Lab File Number : TVB11118036

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	11/19/96	U	0.1	mg/L
Benzene	71-43-2	11/19/96	U	0.4	ug/L
Toluene	108-88-3	11/19/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/19/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/19/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/19/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/19/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/19/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/19/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/19/96	U	0.5	ug/L
FID Surrogate Recovery:		106%		50%-150%	(L)
PID Surrogate Recovery:		101%		50%-150%	(L)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

X. Diane Mulla
Analyst

A. McClellan
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB1112096 Client Project Number : 729691.32010
Date Prepared : 11/20/96 Lab Work Order : 96-4058
Dilution Factor : 1.0 Matrix : Water
Lab File Number : TVB11120007

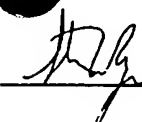
Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/20/96	U	0.1	NA
Benzene	71-43-2	11/20/96	U	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	0.5	ug/L
FID Surrogate Recovery:		104%		50%-150%	(Limits)
Surrogate Recovery:		103%		50%-150%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB1112196 Client Project Number : 729691.32010
Date Prepared : 11/21/96 Lab Work Order : 96-4058
Dilution Factor : 1.0 Matrix : Water
Lab File Number : TVB11120035

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	NA	NA	NA	NA
Benzene	71-43-2	11/21/96	U	0.4	ug/L
Toluene	108-88-3	11/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/21/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/21/96	U	0.5	ug/L
FID Surrogate Recovery:		NA		50%-150%	(Lin
PID Surrogate Recovery:		100%		50%-150%	(L

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman

Analyst

AmCella

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MEB112096 Client Project Number : 729691.32010
Date Prepared : 11/20/96 Lab Work Order : 96-4058
Dilution Factor : 125 Matrix : Water
Lab File Number : TVB11120008


Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	NA	NA	NA	NA
Benzene	71-43-2	11/20/96	U	50	ug/L
Toluene	108-88-3	11/20/96	U	50	ug/L
Chlorobenzene	108-90-7	11/20/96	U	50	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	50	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	50	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	50	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	50	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	50	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	63	ug/L
PID Surrogate Recovery:		NA		50%-150%	(Limits)
FID Surrogate Recovery:		104%		50%-150%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: LF06-MPF-(4-8)'	Client Project Number	: 729691.32010
Lab Sample Number	: 96-4058-01	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Soil
Date Received	: 11/16/96	Lab File Number(s)	: TVB11118050 +
Date Prepared	: 11/19,20/96	Method Blank	: MB1111996 +
FID Dilution Factor	: 5.0	Soil Extracted?	: YES
PID Dilution Factor	: 5.0, 125	Soil Moisture	: 34.94%

Compound Name	Cas Number	Analysis Date	Sample* Concentration	RL*	Units
TVH-Gasoline	----	NA	NA	NA	NA
Benzene	71-43-2	11/19/96	69	3.1	ug/kg
Toluene	108-88-3	11/19/96	10	3.1	ug/kg
Chlorobenzene	108-90-7	11/20/96	4900	77	ug/kg
Ethyl Benzene	100-41-4	11/19/96	84	3.1	ug/kg
Total Xylenes (m,p,o)	1330-20-7	11/19/96	210	3.1	ug/kg
1,3,5-Trimethylbenzene	108-67-8	11/19/96	89	3.1	ug/kg
1,2,4-Trimethylbenzene	95-63-6	11/19/96	240	3.1	ug/kg
1,2,3-Trimethylbenzene	526-73-8	11/19/96	110	3.1	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	11/19/96	190	3.8	ug/kg
FID Surrogate Recovery:		NA		50%-150%	(L)
PID Surrogate Recovery:		70%,109%		50%-150%	(L)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: + = TVB11120009 and MEB112096.

* = Dry Basis

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
 U = Compound analyzed for, but not detected.
 B = Compound also found in the blank.
 J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
 RL = Reporting Limit.
 NA = Not Available/Not Applicable.
 PID = Photoionization detector.
 FID = Flame ionization detector.
 TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

A. McClellan
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St.
Wheat Ridge, CO 80033
(303) 425-6021

SAMPLE Number : 96-4058-01
% WET SOIL : 34.94%
Dilution Factor : 5
Lab File No. :

GAS

Compound Name	Cas Number	SAMPLE Concentration ug/Kg	SAMPLE Concentration x DILN	SAMPLE CONC X % DRY x DILN
TVH-Gasoline	---		0.0	0.0
Benzene	71-43-2	8.973	44.9	69.0
Toluene	108-88-3	1.324	6.6	10.2
Chlorobenzene	108-90-7	288.231	1441.2	2215.1
Ethyl Benzene	100-41-4	10.875	54.4	83.6
m,p-Xylene	108-38-3	24.151	120.8	185.6
	106-42-3			
Xylene	95-47-6	3.416	17.1	26.3
TOTAL XYLENE			137.8	137.8
1,3,5-Trimethylbenzene	108-67-8	11.582	57.9	89.0
1,2,4-Trimethylbenzene	95-63-6	31.249	156.2	240.2
1,2,3-Trimethylbenzene	526-73-8	13.921	69.6	107.0
1,2,3,4-Tetramethylbenzene	488-23-3	24.999	192.1	192.1

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St.
Wheat Ridge, CO 80033
(303) 425-6021

SAMPLE Number : 96-4058-01
% WET SOIL : 34.94%
Dilution Factor : 125
Lab File No. :

Compound Name	Cas Number	SAMPLE Concentration ug/Kg	SAMPLE CONC X % DRY
TVH-Gasoline	---		0.0
Benzene	71-43-2		0.0
Toluene	108-88-3		0.0
Chlorobenzene	108-90-7	3204.438	4925.4
Ethyl Benzene	100-41-4		0.0
m,p-Xylene	108-38-3		0.0
	106-42-3		
o-Xylene	95-47-6		0.0
TOTAL XYLENE			0.0
1,3,5-Trimethylbenzene	108-67-8		0.0
1,2,4-Trimethylbenzene	95-63-6		0.0
1,2,3-Trimethylbenzene	526-73-8		0.0
1,2,3,4-Tetramethylbenzene	488-23-3		0.0

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF06-MPF-(8-10)' Client Project Number : 729691.32010
Lab Sample Number : 96-4058-02 Lab Work Order : 96-4058
Date Sampled : 11/15/96 Matrix : Soil
Date Received : 11/16/96 Lab File Number(s) : TVB11120058
Date Prepared : 11/21/96 Method Blank : MB1112196
FID Dilution Factor : 1.0 Soil Extracted? : NO
PID Dilution Factor : 1.0 Soil Moisture : 15.41%

Compound Name	Cas Number	Analysis Date	Sample* Concentration	RL *	Units
TVH-Gasoline	---	NA	NA	NA	NA
Benzene	71-43-2	11/21/96	U	0.5	ug/kg
Toluene	108-88-3	11/21/96	1.4	0.5	ug/kg
Chlorobenzene	108-90-7	11/21/96	0.7	0.5	ug/kg
Ethyl Benzene	100-41-4	11/21/96	U	0.5	ug/kg
Total Xylenes (m,p,o)	1330-20-7	11/21/96	U	0.5	ug/kg
1,3,5-Trimethylbenzene	108-67-8	11/21/96	U	0.5	ug/kg
1,2,4-Trimethylbenzene	95-63-6	11/21/96	U	0.5	ug/kg
1,2,3-Trimethylbenzene	526-73-8	11/21/96	U	0.5	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	11/21/96	U	0.6	ug/kg
Surrogate Recovery:		NA		50%-150%	(Limits)
Surrogate Recovery:		75%		50%-150%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: * = Dry Basis

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.

RL = Reporting Limit.

NA = Not Available/Not Applicable.

PID = Photoionization detector.

FID = Flame ionization detector.

TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: W79	Client Project Number	: 729691.32010
Lab Sample Number	: 96-4058-03	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Water
Date Received	: 11/16/96	Lab File Number(s)	: TVB11120010
Date Prepared	: 11/20/96	Method Blank	: MB1112096
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

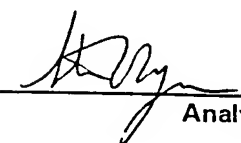
Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	11/20/96	U	0.1	mg/L
Benzene	71-43-2	11/20/96	U	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	0.5	ug/L
FID Surrogate Recovery:		103%		50%-150%	(L)
PID Surrogate Recovery:		107%		50%-150%	(L)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
 U = Compound analyzed for, but not detected.
 B = Compound also found in the blank.
 J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
 RL = Reporting Limit.
 NA = Not Available/Not Applicable.
 PID = Photoionization detector.
 FID = Flame ionization detector.
 TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : W82 Client Project Number : 729691.32010
Lab Sample Number : 96-4058-04 Lab Work Order : 96-4058
Date Sampled : 11/15/96 Matrix : Water
Date Received : 11/16/96 Lab File Number(s) : TVB11120017
Date Prepared : 11/20/96 Method Blank : MB1112096
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

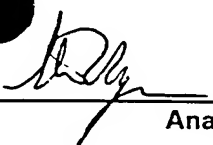
Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/20/96	U	0.1	mg/L
Benzene	71-43-2	11/20/96	U	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	0.5	ug/L
Surrogate Recovery:		97%		50%-150%	(Limits)
Surrogate Recovery:		97%		50%-150%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPH Client Project Number : 729691.32010
Lab Sample Number : 96-4058-05 Lab Work Order : 96-4058
Date Sampled : 11/15/96 Matrix : Water
Date Received : 11/16/96 Lab File Number(s) : TVB11120018
Date Prepared : 11/20/96 Method Blank : MB1112096
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	11/20/96	U	0.1	mg/L
Benzene	71-43-2	11/20/96	U	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	0.5	ug/L
FID Surrogate Recovery:		99%		50%-150%	(L)
PID Surrogate Recovery:		101%		50%-150%	(L)


Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPL Client Project Number : 729691.32010
Lab Sample Number : 96-4058-06 Lab Work Order : 96-4058
Date Sampled : 11/15/96 Matrix : Water
Date Received : 11/16/96 Lab File Number(s) : TVB11120019
Date Prepared : 11/20/96 Method Blank : MB1112096
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	11/20/96	U	0.1	mg/L
Benzene	71-43-2	11/20/96	U	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	8.5	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	0.5	ug/L
FID Surrogate Recovery:		102%		50%-150%	(Limits)
Surrogate Recovery:		102%		50%-150%	(Limits)

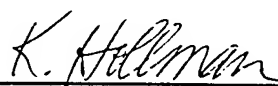
Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: W18	Client Project Number	: 729691.32010
Lab Sample Number	: 96-4058-07	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Water
Date Received	: 11/16/96	Lab File Number(s)	: TVB11120020
Date Prepared	: 11/20/96	Method Blank	: MB1112096
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		


Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/20/96	U	0.1	mg/L
Benzene	71-43-2	11/20/96	1.3	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	22	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	0.5	ug/L
FID Surrogate Recovery:		100%		50%-150%	(L)
PID Surrogate Recovery:		101%		50%-150%	(L)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
 U = Compound analyzed for, but not detected.
 B = Compound also found in the blank.
 J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
 RL = Reporting Limit.
 NA = Not Available/Not Applicable.
 PID = Photoionization detector.
 FID = Flame ionization detector.
 TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPK Client Project Number : 729691.32010
Lab Sample Number : 96-4058-08 Lab Work Order : 96-4058
Date Sampled : 11/15/96 Matrix : Water
Date Received : 11/16/96 Lab File Number(s) : TVB11120021
Date Prepared : 11/20/96 Method Blank : MB1112096
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

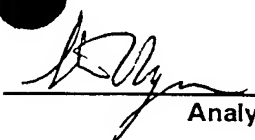
Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	11/20/96	U	0.1	mg/L
Benzene	71-43-2	11/20/96	0.4	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	11	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	0.5	ug/L
Surrogate Recovery:		94%		50%-150%	(Limits)
Surrogate Recovery:		96%		50%-150%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
 4036 Youngfield St. Wheat Ridge, CO 80033
 (303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: LF6-MPI	Client Project Number	: 729691.32010
Lab Sample Number	: 96-4058-09	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Water
Date Received	: 11/16/96	Lab File Number(s)	: TVB11120022
Date Prepared	: 11/20/96	Method Blank	: MB1112096
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

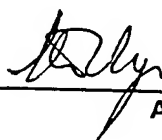
Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/20/96	U	0.1	mg/L
Benzene	71-43-2	11/20/96	0.7	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	2.7	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	0.5	ug/L
FID Surrogate Recovery:		97%		50%-150%	(L)
PID Surrogate Recovery:		98%		50%-150%	(L)


Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

- E = Extrapolated value. Value exceeds calibration range.
- U = Compound analyzed for, but not detected.
- B = Compound also found in the blank.
- J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
- RL = Reporting Limit.
- NA = Not Available/Not Applicable.
- PID = Photoionization detector.
- FID = Flame ionization detector.
- TVH = Total Volatile Hydrocarbons.


 Analyst


 Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : Trip Blank Client Project Number : 729691.32010
Lab Sample Number : 96-4058-10 Lab Work Order : 96-4058
Date Sampled : NA Matrix : Water
Date Received : 11/16/96 Lab File Number(s) : TVB11120023
Date Prepared : 11/20/96 Method Blank : MB1112096
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	11/20/96	U	0.1	mg/L
Benzene	71-43-2	11/20/96	U	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	0.5	ug/L
Surrogate Recovery:		98%		50%-150%	(Limits)
Surrogate Recovery:		100%		50%-150%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: LF06-MPF-(8-10)'	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-02	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	EPA Method No.	: 602/8020
Date Received	: 11/16/96	Matrix	: Soil
Date Prepared	: 11/19/96	Lab File Number(s)	: TVB11118054,55
Date Analyzed	: 11/19/96	Method Blank	: MB1111996
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (ug/kg)	Sample Concentration (ug/kg)	Concentration (ug/kg)		Comments
			MS	MSD	
Benzene	20.0	0.0	18.5	16.6	
Toluene	20.0	1.1	18.2	16.4	
Chlorobenzene	20.0	0.6	18.4	16.4	
Ethylbenzene	20.0	0.0	17.7	16.0	
m,p-Xylene	20.0	0.0	17.1	15.4	
o-Xylene	20.0	0.0	17.2	15.5	
1,3,5-TMB	20.0	0.0	17.7	16.2	
1,2,4-TMB	20.0	0.0	17.1	15.9	
1,2,3-TMB	20.0	0.0	17.2	16.1	
1,2,3,4-TeMB	20.0	0.0	16.1	14.4	
Surrogate	100.0	75%	74%	76%	% RECOVERY

Compound		MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits		
					RPD	%REC	
Benzene		92.5	83.0	10.8	21	49	126
Toluene		85.5	76.5	11.1	25	46	131
Chlorobenzene		89.0	79.0	11.9	19	56	116
Ethylbenzene		88.5	80.0	10.1	25	35	133
m,p-Xylene		85.5	77.0	10.5	27	37	133
o-Xylene		86.0	77.5	10.4	27	37	131
1,3,5-TMB		88.5	81.0	8.8	24	48	123
1,2,4-TMB		85.5	79.5	7.3	23	43	125
1,2,3-TMB		86.0	80.5	6.6	23	44	123
1,2,3,4-TeMB		80.5	72.0	11.1	23	33	127
Surrogate		74.0	76.0	NA	NA	72	118

= Limits established 10/1/96,HDM

* = Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments: _____

K. Hallman
Analyst

A. McCell
Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: W79	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-03	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	EPA Method No.	: 602/8020
Date Received	: 11/16/96	Matrix	: Water
Date Prepared	: 11/20/96	Lab File Number(s)	: TVB11120013,14
Date Analyzed	: 11/20/96	Method Blank	: MB1112096
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L)		Comments
			MS	MSD	
Benzene	20.0	0.0	19.4	19.9	
Toluene	20.0	0.0	18.8	19.3	
Chlorobenzene	20.0	0.0	18.6	19.4	
Ethylbenzene	20.0	0.0	18.8	19.5	
m,p-Xylene	20.0	0.0	18.5	19.0	
o-Xylene	20.0	0.0	18.9	19.2	
1,3,5-TMB	20.0	0.0	19.3	20.1	
1,2,4-TMB	20.0	0.0	19.0	19.4	
1,2,3-TMB	20.0	0.0	19.4	19.6	
1,2,3,4-TeMB	20.0	0.0	18.6	19.7	
Surrogate	100.0	107%	103%	103%	% RECOVERY

Compound	MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits	
				RPD	%REC
Benzene	97.0	99.5	2.5	18	62 - 129
Toluene	94.0	96.5	2.6	25	55 - 133
Chlorobenzene	93.0	97.0	4.2	9	66 - 122
Ethylbenzene	94.0	97.5	3.7	15	60 - 127
m,p-Xylene	92.5	95.0	2.7	20	44 - 146
o-Xylene	94.5	96.0	1.6	16	57 - 131
1,3,5-TMB	96.5	100.5	4.1	16	63 - 129
1,2,4-TMB	95.0	97.0	2.1	16	55 - 136
1,2,3-TMB	97.0	98.0	1.0	13	64 - 127
1,2,3,4-TeMB	93.0	98.5	5.7	23	53 - 132
Surrogate	103.0	103.0	NA	NA	82 - 115

= Limits established 10/1/96,HDM


* = Values outside of QC limits.

RPD: 0 out of (10) outside limits.

Spike Recovery: 0 out of (20) outside limits.

Comments:


Analyst


Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: W79	Client Project No	: 729691.32010
Lab Sample No.	: 96-4058-03	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 11/16/96	Matrix	: Water
Date Prepared	: 11/20/96	Lab File Number(s)	: TVB11120011,12
Date Analyzed	: 11/20/96	Method Blank	: MB1112096
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#)
					Limits
Gasoline	2.00	0.00	1.92	96.0%	62 - 126
Surrogate **	---	---	---	109%	70 - 121

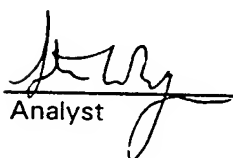
Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#)	
					Limits	
Gasoline	2.00	2.16	108.0%	11.8	42.3	62 - 126
Surrogate **	---	---	109%	NA	NA	70 - 121

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.


Notes:

NA = Not analyzed/not applicable.
* = Values outside of QC limits.
** = 1,2,4-Trichlorobenzene
= Limits established 10/2/96, KSH

Comments: _____



Analyst



Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: <u>LCS1111996</u>	Matrix	: <u>Water</u>
Date Prepared	: <u>11/19/96</u>	Method Numbers	: <u>EPA 5030/8015 Modified</u>
Date Analyzed	: <u>11/19/96</u>	Instrument Name	: <u>TVHBTEX1</u>
Lab File Number(s)	: <u>TVB11118048</u>		

<u>Compound Name</u>	<u>Theoretical Concentration (mg/L)</u>	<u>LCS Concentration (mg/L)</u>	<u>LCS % Recovery</u>	<u>QC Limit % Recovery</u>
Gasoline	2.00	2.12	106.0	83 - 120

Surrogate Recovery:	105%	70 - 121
---------------------	------	----------

QUALIFIERS

B = TVH as Gasoline found in blank also.

E = Extrapolated value. Value exceeds calibration range.

NA = Not Available/Not Applicable.

** = Limits established 9/24/96 for TVHBTEX1. HDM

H. Diane Mills
Analyst

A. McChella
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St.
Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number : LCS1111996
Date Extracted/Prepared : 11/19/96
Date Analyzed : 11/19/96
Spike Amount (ug/L) : 20.0

Dilution Factor : 1.00
Method : 602/8020
Matrix : Water
Lab File No. : TVB11118049

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	20.7	103.5	75 - 110
Toluene	108-88-3	19.7	98.5	75 - 110
Chlorobenzene	108-90-7	18.1	90.5	69 - 110
Ethyl Benzene	100-41-4	19.5	97.5	74 - 110
m,p-Xylene	108-38-3	37.2	93.0	73 - 110
o-Xylene	106-42-3	19.4	97.0	74 - 110
MTBE	1634-04-4	19.7	98.5	59 - 129
1,3,5-Trimethylbenzene	108-67-8	20.0	100.0	70 - 110
1,2,4-Trimethylbenzene	95-63-6	18.4	92.0	73 - 110
1,2,3-Trimethylbenzene	526-73-8	22.3	111.5	84 - 122
1,2,3,4-Tetramethylbenzene	488-23-3	19.2	96.0	67 - 116
Surrogate Recovery:		100%		82 - 115

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:

E = Extrapolated value. Value exceeds that of the calibration range.
U = Compound analyzed for, but not detected.
B = Compound found in blank and sample. Compare blank and sample data.
NA = Not available/Not analyzed.
** = Limits updated 10/02/96 for TVHBTEX1. SWT

Analyst

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St.
Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number : LCS1112096
Date Extracted/Prepared : 11/20/96
Date Analyzed : 11/20/96
Spike Amount (ug/L) : 20.0

Dilution Factor : 1.00
Method : 602/8020
Matrix : Water
Lab File No. : TVB11120006

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	20.9	104.5	75 - 110
Toluene	108-88-3	19.7	98.5	75 - 110
Chlorobenzene	108-90-7	20.2	101.0	69 - 110
Ethyl Benzene	100-41-4	20.3	101.5	74 - 110
m,p-Xylene	108-38-3	38.5	96.3	73 - 110
	106-42-3			
Xylene	95-47-6	20.1	100.5	74 - 114
	1634-04-4	18.2	91.0	59 - 129
1,3,5-Trimethylbenzene	108-67-8	21.3	106.5	70 - 110
1,2,4-Trimethylbenzene	95-63-6	19.2	96.0	73 - 110
1,2,3-Trimethylbenzene	526-73-8	24.2	121.0	84 - 122
1,2,3,4-Tetramethylbenzene	488-23-3	22.1	110.5	67 - 116
Surrogate Recovery:		105%		82 - 115

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:

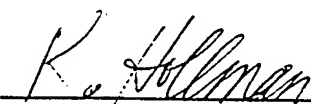
E = Extrapolated value. Value exceeds that of the calibration range.

U = Compound analyzed for, but not detected.

B = Compound found in blank and sample. Compare blank and sample data.

NA = Not available/Not analyzed.

= Limits updated 10/02/96 for TVHBTEX1. SWT


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number : LCS1112096 Matrix : Water
Date Prepared : 11/20/96 Method Numbers : EPA 5030/8015 Modified
Date Analyzed : 11/20/96 Instrument Name : TVHBTEX1
Lab File Number(s) : TVB11120005

<u>Compound Name</u>	<u>Theoretical Concentration (mg/L)</u>	<u>LCS Concentration (mg/L)</u>	<u>LCS % Recovery</u>	<u>QC Limit % Recovery</u>
Gasoline	2.00	2.33	116.5	83 - 120
<hr/>				
Surrogate Recovery:		110%		70 - 121

QUALIFIERS

B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA = Not Available/Not Applicable.
** = Limits established 9/24/96 for TVHBTEX1. HDM

Ray
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Method Blank Report

Method Blank : RB112096 Client Project No. : 729691.32010
Date Prepared : 11/20/96 Lab Project No. : 96-4058
Date Analyzed : 11/20/96 Lab File No. : HALL1120\004F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 88% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 8010 Chlorinated VOC's Method Blank Report

Method Blank : RB112196 Client Project No. : 729691.32010
Date Prepared : 11/21/96 Lab Project No. : 96-4058
Date Analyzed : 11/21/96 Lab File No. : HALL1121\004F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 81% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Method Blank Report

Method Blank : MB112696 Client Project No. : 729691.32010
Date Prepared : 11/26/96 Lab Project No. : 96-4058
Date Analyzed : 11/26/96 Lab File No. : HALL1126\004F0101

<u>Compound</u>	<u>CAS #</u>	<u>Concentration (ug/L)</u>	<u>RL(ug/L)</u>
Chlorobenzene	108-90-7	U	0.42

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 87% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:



Analyst



Approved

HLW4058.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : LF06-MPF-(4'-8') Client Project No. : 729691.32010
Lab Sample No. : 96-4058-01 Lab Project No. : 96-4058
Date Sampled : 11/15/96 Matrix : Soil
Date Received : 11/16/96 Lab File No. : HALL1120\017F0101
Date Prepared : 11/20/96 Method Blank : RB112096
Date Analyzed : 11/20/96 Dilution Factor : 1.6
Percent Moisture : 34.94

Compound	CAS #	Concentration(ug/Kg)	RL(ug/Kg)
Vinyl Chloride	75-01-4	U	0.63
Chloroethane	75-00-3	U	0.63
1,1-Dichloroethene	75-35-4	U	0.63
Dichloromethane	75-09-2	U	0.63
trans-1,2-Dichloroethene	156-60-5	U	0.63
1,1-Dichloroethane	75-34-3	U	0.63
cis-1,2-Dichloroethene	156-59-4	U	0.63
1,1,1-Trichloroethane	71-55-6	U	0.63
Carbon Tetrachloride	56-23-5	U	0.63
Trichloroethene	79-01-6	U	0.63
1,1,2-Trichloroethane	79-00-5	U	0.63
Tetrachloroethene	127-18-4	U	0.63
1,1,1,2-Tetrachloroethane	79-00-5	U	0.63
Chlorobenzene	108-90-7	E	0.66
1,1,2,2-Tetrachloroethane	79-34-5	U	0.84
2-Chlorotoluene	95-49-8	U	0.63
4-Chlorotoluene	106-49-8	U	0.63
1,3-Dichlorobenzene	541-73-1	12	0.63
1,2-Dichlorobenzene	95-50-1	7.7	0.63

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 95% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 12/3/96

QUANT. PLYMER

Page 1

Job: 10: 101
 Output File: 00287:01
 Date: 10/17/87:01
 File: 00-4078-01
 Name: 5;5;5.02;1;5;5;11/21/93;0

Quant: 1
 Date: 10/17/87
 Location: 10:02
 Division Factor: 1.00000
 Instrument ID: 001 1

ID File: ID-024:01
 Title: ID FILE FOR APPENDIX DIVE WAS METHOD 826-200140
 Last Calibration: 9/11/87 10:16
 List Used: 10:02

	Compound	M.T.	Std #	Area	Wt. %	Unit	
10	1,2-DICHLOROETHANE (INT. STD)	6.12	100	26124	50.00	US/L	82
11	1,1,1-TRICHLOROETHANE	7.92	100	1017	1.22	US/L	82
12	1,2-DICHLOROETHANE-D4 (FOR STD)	7.17	100	61201	48.14	US/L	107
13	1,2-DICHLOROETHANE (INT. STD)	8.62	100	11011	50.00	US/L	100
14	1,2-DICHLOROETHANE-D5 (INTERNAL STD)	14.46	100	10223	50.00	US/L	107
15	1,2-DICHLOROETHANE (SURROGATE STD)	11.51	100	11212	61.35	US/L	100
16	1,2-DICHLOROETHANE	14.53	100	4487901	37.35	US/L	100
17	8-ETHYLCHLOROBENZENE (SURR. STD)	17.07	100	60503	61.44	US/L	100
18	1,2-DICHLOROBENZENE	18.38	100	59761M	44.70	US/L	95
19	1,2-DICHLOROBENZENE	20.37	100	20019	19.53	US/L	77
20	1,4-DICHLOROBENZENE	19.61	100	149502	105.88	US/L	95

* Compound is 1810

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06-MPF-(4'-8')	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-01	Lab Project No.	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Soil
Date Received	: 11/16/96	Lab File No.	: HALL1126\008F0101
Date Prepared	: 11/26/96	Method Blank	: MB112696
Date Analyzed	: 11/26/96	Dilution Factor	: 191.2
Percent Moisture	: 34.94		

<u>Compound</u>	<u>CAS #</u>	<u>Concentration(ug/Kg)</u>	<u>RL(ug/Kg)</u>
Chlorobenzene	108-90-7	1300	80

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 96% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06-MPF-(8'-10')	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-02	Lab Project No.	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Soil
Date Received	: 11/16/96	Lab File No.	: HALL1120\015F0101
Date Prepared	: 11/20/96	Method Blank	: RB112096
Date Analyzed	: 11/20/96	Dilution Factor	: 1.2
Percent Moisture	: 15.41		

Compound	CAS #	Concentration(ug/Kg)	RL(ug/Kg)
Vinyl Chloride	75-01-4	1.7 J X	0.47
Chloroethane	75-00-3	U	0.47
1,1-Dichloroethene	75-35-4	U	0.47
Dichloromethane	75-09-2	0.89 J X	0.47
trans-1,2-Dichloroethene	156-60-5	U	0.47
1,1-Dichloroethane	75-34-3	U	0.47
cis-1,2-Dichloroethene	156-59-4	U	0.47
1,1,1-Trichloroethane	71-55-6	U	0.47
Carbon Tetrachloride	56-23-5	U	0.47
Trichloroethene	79-01-6	U	0.47
1,1,2-Trichloroethane	79-00-5	U	0.47
Tetrachloroethene	127-18-4	U	0.47
1,1,1,2-Tetrachloroethane	79-00-5	U	0.47
Chlorobenzene	108-90-7	2 J	0.49
1,1,2,2-Tetrachloroethane	79-34-5	U	0.63
2-Chlorotoluene	95-49-8	U	0.47
Chlorotoluene	106-49-8	U	0.47
1,3-Dichlorobenzene	541-73-1	U	0.47
1,2-Dichlorobenzene	95-50-1	U	0.47

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 97% 70% - 130% (QC limits)

QUALIFIERS:

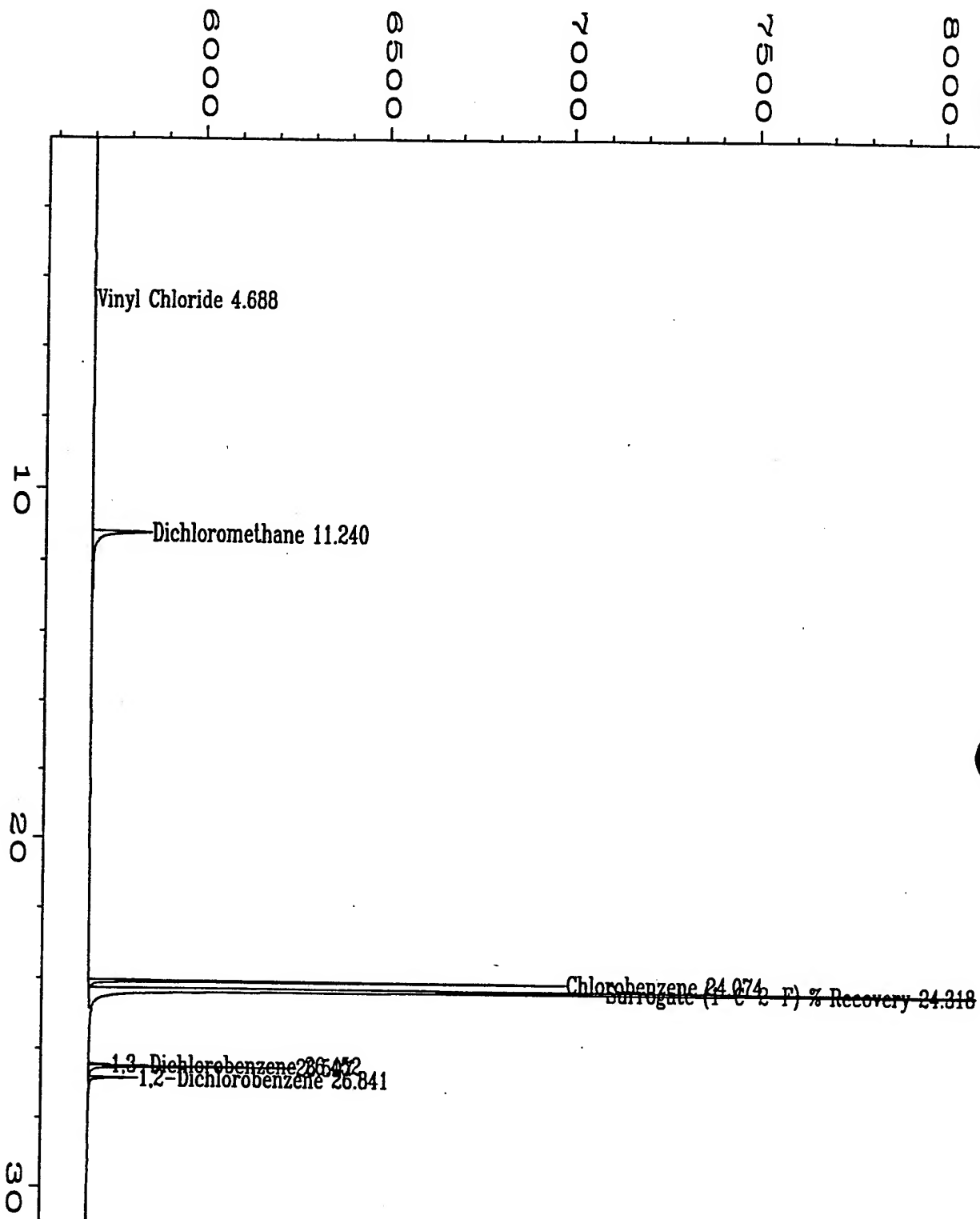
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES: X = Not confirmed by MS (MDL = 1ug/Kg).

Analyst

Approved

HLW4058.XLS; 12/5/96



Data File Name	: C:\HPCHEM\1\DATA\hall11120\015F0101.D	Page Number	: 1
Operator	: John Parker	Vial Number	: 15
Instrument	: HALL	Injection Number	: 1
Sample Name	: 96-4058-02B	Sequence Line	: 1
Run Time Bar Code:		Instrument Method	: PES111
Acquired on	: 20 Nov 96 05:55 PM	Analysis Method	: PES111
Report Created on:	20 Nov 96 06:26 PM	Sample Amount	: 0
Last Recalib on	: 18 NOV 96 05:47 PM	ISTD Amount	:
Multiplier	: 1		
Sample Info	: SAMP 8010 S		
	: :5.06g LF06-MPF-(8'-10')		

QUANT REPORT

Page 1

Operator ID: KIM
Output File: ^U2947::Q1
Data File: >U2947::U2
Name: RB112796 ;;;KL
Misc: S;W;0;1;W;0;11/27/96;0

Quant Rev: 7 Quant Time: 961127 10:50
 Injected at: 961127 10:34
Dilution Factor: 1.00000
Instrument ID: VOA 1

ID File: ID_824::QT

Title: ID FILE FOR APPENDIX NINE VOAs METHOD 8260A(8240)

Last Calibration: 961125 12:35

Last Qual Time: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	g
1)	*BROMOCHLOROMETHANE(INT STD)	6.14	584	37231M	50.00	UG/L	76
4)	BROMOMETHANE	1.29	94	1518	2.16	UG/L	100
23)	1,2-DICHLOROETHANE-D4(SUR STD)	7.45	716	87087	50.49	UG/L	100
24)	*1,4-DIFLUOROBENZENE(INT STD)	8.60	832	174566	50.00	UG/L	100
46)	*CHLOROBENZENE-D5(INTERNAL STD)	14.42	1419	144891	50.00	UG/L	100
53)	TOLUENE-D8(SURROGATE STD)	11.50	1124	182569	49.38	UG/L	100
58)	BROMOFLUOROBENZENE(SURR STD)	17.04	1683	95316	47.23	UG/L	100

* Compound is ISTD

QUANT REPORT

Page 1

Operator ID: KIM
Output File: ^02958::Q1
Data File: ^02958::U2
Name: 96-4058-02 ;;;KL
Misc: 5;S;5.01;1;S;0;11/27/96;0

Quant Rev: 7 Quant Time: 961127 16:04
 Injected at: 961127 15:39
Dilution Factor: 1.00000
Instrument ID: VOA 1

ID File: ID_824::Q1

Title: ID FILE FOR APPENDIX NINE VUAs METHOD 8260A(8240)

Last Calibration: 961125 12:35

Last Cal Time: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	g
1)	*BROMOCHLOROMETHANE(INT STD)	6.10	579	31481	50.00	UG/L	7
4)	BROMOMETHANE	1.27	92	875	1.47	UG/L	10
23)	1,2-DICHLOROETHANE-D4(SUR STD)	7.43	714	75078	51.47	UG/L	10
24)	*1,4-DIFLUOROBENZENE(INT STD)	8.58	830	170251	50.00	UG/L	10
46)	*CHLOROBENZENE-D5(INTERNAL STD)	14.41	1418	139638	50.00	UG/L	10
53)	TOLUENE-D8(SURROGATE STD)	11.48	1122	180579	50.68	UG/L	10
55)	CHLOROBENZENE	14.47	1424	4147	1.44	UG/L	10
58)	BROMOFLUOROBENZENE(SURR STD)	17.04	1683	91009	46.79	UG/L	10
64)	1,4-DICHLOROBENZENE	19.61	1942	1412	.555	UG/L	9

* Compound is ISTD

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: W79	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-03	Lab Project No.	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Water
Date Received	: 11/16/96	Lab File No.	: HALL1120\027F0101
Date Prepared	: 11/20/96	Method Blank	: RB112096
Date Analyzed	: 11/21/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
3-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 81% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : W82	Client Project No. : 729691.32010
Lab Sample No. : 96-4058-04	Lab Project No. : 96-4058
Date Sampled : 11/15/96	Matrix : Water
Date Received : 11/16/96	Lab File No. : HALL1121\006F0101
Date Prepared : 11/21/96	Method Blank : RB112196
Date Analyzed : 11/21/96	Dilution Factor : 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	1.4	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	0.73 J	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 84% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
 B = Compound in blank and sample. Compare blank and sample data.
 E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
 RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6-MPH	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-05	Lab Project No.	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Water
Date Received	: 11/16/96	Lab File No.	: HALL1121\007F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/21/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
3-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 80% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6-MPL	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-06	Lab Project No.	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Water
Date Received	: 11/16/96	Lab File No.	: HALL1121\008F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/21/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	2.1 J	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	3.7	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 79% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 12/5/96

QUANT REPORT

Page: 1

Sample ID: KIM
 Output File: Q02885::Q1
 Data File: >Q02885::S1
 Name: 96-4008-06 ;;;KL
 Misc: S;W;U;1;W;U;11/21/96;U

Quant Rev: / Quant Time: 961121 17:51
 Injected at: 961121 17:27
 Dilution Factor: 1.00000
 Instrument ID: VQA 1

ID File: ID_824::Q1
 Title: ID FILE FOR APPENDIX NINE VQAs METHOD 826VQA(8240
 Last Calibration: 961120 10:56 Last Qcal Time: <none>

Compound	R.T.	Scan#	Area	Conc	Units	%
1) BROMOCHLOROMETHANE (INT STD)	6.17	587	35284	50.00	UG/L	82
2) VINYL CHLORIDE	6.98	63	4911	3.58	UG/L	100
13) 1,2-DICHLOROETHANE-D4 (SUR STD)	7.50	721	83665	46.52	UG/L	100
24) *1,4-DIFLUOROBENZENE (INT STD)	8.64	836	129557	50.00	UG/L	100
46) *CHLOROBENZENE-D5 (INTERNAL STD)	14.45	1422	146181	50.00	UG/L	100
53) TOLUENE-D8 (SURROGATE STD)	11.52	1126	184089	48.26	UG/L	100
55) CHLOROBENZENE	14.50	1427	27233	8.96	UG/L	100
58) BROMOFLUOROBENZENE (SURR STD)	17.06	1685	100846	49.24	UG/L	100
64) 1,4-DICHLOROBENZENE	19.60	1941	31161	10.60	UG/L	97

* Compound is 1S19

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: W18	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-07	Lab Project No.	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Water
Date Received	: 11/16/96	Lab File No.	: HALL1121\009F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/21/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	4.9	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	1.3	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	13	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	0.78 J	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 90% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 11/27/96

QUANT REPORT

Page 1

Lab ID: KIM
Report File: 002888::Q1
Data File: 002888::S1
Name: 96-4058-U7 ;;;KL
Misc: 5;0;0;1;0;0;11/21/96;0

Quant Rev: / Quant Line: 961122 04:30
Injected at: 961121 19:02
Dilution Factor: 1.00000
Instrument ID: UUA 1

ID File: ID_824::QT
Title: ID FILE FOR APPENDIX NINE UOAS METHUD 826UA(8240)
Last Calibration: 961120 10:56 Last Qual Time: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	C
1)	BROMOCHLOROMETHANE (INT STD)	6.18	587	35466	50.00	UG/L	28
4)	BROMOMETHANE	1.29	94	677	.997	UG/L	100
5)	VINYL CHLORIDE	.98	63	11576	8.39	UG/L	100
17)	1,1-DICHLOROETHANE	4.17	385	3730M	1.40	UG/L	100
19)	CIS 1,2-DICHLOROETHENE	5.64	533	2834M	2.15	UG/L	39
23)	1,2-DICHLOROETHANE-D4 (SUR STD)	7.48	718	84528	46.75	UG/L	100
24)	1,4-DIFLUOROBENZENE (INT STD)	8.62	833	172245	50.00	UG/L	100
46)	*CHLOROBENZENE-D5 (INTERNAL STD)	14.42	1418	143780	50.00	UG/L	100
53)	TOLUENE-D8 (SURROGATE STD)	11.48	1122	179533	47.85	UG/L	100
55)	CHLOROBENZENE	14.47	1423	73220	24.21	UG/L	100
58)	BROMOFLUOROBENZENE (SURR STD)	17.04	1683	95978	47.64	UG/L	100
62)	1,2-DICHLOROBENZENE	20.40	2021	2612	.990	UG/L	96
64)	1,4-DICHLOROBENZENE	19.60	1941	36364	12.58	UG/L	98

* Compound is ISID

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6-MPK	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-08	Lab Project No.	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Water
Date Received	: 11/16/96	Lab File No.	: HALL1121\010F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/21/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	3	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	6.1	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	0.55 J	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 85% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 11/27/96

QUANT REPORT

Page 1

Operator ID: KIM
 Output File: 002889::Q1
 Data File: >002889::S1
 Name: 96-4058-U8 ;;;KL
 Method: 5;W;0;1;0;0;11/21/96;0

Quant Rev: / Quant Time: 961122 04:31
 Injected at: 961121 19:36
 Dilution Factor: 1.00000
 Instrument ID: VOA 1

ID File: ID_824::Q1

Title: ID FILE FOR APPENDIX NINE VOAs METHOD 8260A(8240)

Last Calibration: 961120 10:56

Last Qcal Time: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	%
1)	BROMOCHLOROMETHANE (INT STD)	6.12	582	37284	50.00	UG/L	78
4)	BROMOMETHANE	1.29	94	723	.999	UG/L	100
5)	VINYL CHLORIDE	.97	62	7686	5.23	UG/L	100
22)	1,2-DICHLORoETHANE-D4 (SUR STD)	7.45	716	91270	42.38	UG/L	100
24)	1,4-DIFLUOROBENZENE (INT STD)	8.61	853	188208	50.00	UG/L	100
46)	CHLOROBENZENE-D5 (INTERNAL STD)	14.44	1421	156166	50.00	UG/L	100
53)	TOLUENE-D8 (SURROGATE STD)	11.50	1124	195768	48.04	UG/L	100
55)	CHLOROBENZENE	14.49	1426	38454	11.71	UG/L	100
58)	BROMOFLUOROBENZENE (SURR STD)	17.06	1685	108572	49.62	UG/L	100
63)	1,2-DICHLOROBENZENE	20.38	2020	2592	.905	UG/L	99
64)	1,4-DICHLOROBENZENE	19.61	1942	36981	11.78	UG/L	96

* Compound is ISID

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : LF6-MPI
Lab Sample No. : 96-4058-09
Date Sampled : 11/15/96
Date Received : 11/16/96
Date Prepared : 11/21/96
Date Analyzed : 11/21/96
Client Project No. : 729691.32010
Lab Project No. : 96-4058
Matrix : Water
Lab File No. : HALL1121\011F0101
Method Blank : RB112196
Dilution Factor : 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	3.4	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	1.8	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 78% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 11/27/96

QUANT REPORT

Page 1

Operator ID: KIM
Output File: >02890::Q1
Data File: >02890::S1
Name: 96-4058-09 ;;;KL
Misc: 5;0;0;1;0;0;11/21/96;0

Quant Rev: 2 Quant Time: 961122 14:51
Injected at: 961122 20:03
Dilution Factor: 1.00000
Instrument ID: UUA 1

ID File: ID_824::Q1
Title: ID FILE FOR APPENDIX NINE UOAS METHOD 8260A(8240)
Last Calibration: 961120 10:56 Last Qual Time: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	Q
10	*BROMOCHLOROMETHANE(INT STD)	6.15	585	36383	50.00	UG/L	82
50	VINYL CHLORIDE	.98	63	8448M	5.97	UG/L	100
110	METHYLENE CHLORIDE	2.91	258	1863	1.54	UG/L	47
170	1,1-DICHLOROETHANE	4.16	384	1740M	.638	UG/L	100
190	CIS 1,2-DICHLOROETHENE	5.62	531	4014M	2.97	UG/L	79
230	1,2-DICHLOROETHANE-D4(SUR STD)	7.47	718	86695	46.74	UG/L	100
240	*1,4-DIFLUOROBENZENE(INT STD)	8.62	834	184480	50.00	UG/L	100
460	*CHLOROBENZENE-D5(INTERNAL STD)	14.43	1420	154115	50.00	UG/L	100
530	TOLUENE-D8(SURROGATE STD)	11.50	1124	191515	47.62	UG/L	100
550	CHLOROBENZENE	14.48	1425	5758	1.78	UG/L	100
580	BROMOFLUOROBENZENE(SURR STD)	17.04	1683	101581	47.04	UG/L	100
640	1,4-DICHLOROBENZENE	19.62	1943	3904	1.26	UG/L	81

* Compound is 1STD

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: Trip Blank	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-10	Lab Project No.	: 96-4058
Date Sampled	: 11/15/96	Matrix	: Water
Date Received	: 11/16/96	Lab File No.	: HALL1121\012F0101
Date Prepared	: 11/21/96	Method Blank	: RB112196
Date Analyzed	: 11/21/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 79% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4058.XLS; 11/27/96

Method 8010 Control Samples

Date Performed: 11/25/96

Reference Standard: V832

Analyte	M	Method Blank	Sample 96-4088-03	Sample Spike	Spike Dup.	Control Spike	Spike Amt	RPD	Spike Recoveries			QC Recovery Range		
									Sample	Dup	# Control	% L - % H	Low	High
Vinyl Chloride	W			13.191	15.032	12.340	20.0	13.0	66%	75%		62%	28 - 163	5.60 - 32.60
Chloroethane	*			16.194	17.032	15.169	20.0	5.0	81%	85%		76%	46 - 137	9.20 - 27.40
1,1-Dichloroethane	*			16.112	16.76	14.989	20.0	3.9	81%	84%		75%	28 - 167	5.60 - 33.40
Dichloromethane	*			16.801	17.482	15.865	20.0	4.0	84%	87%		79%	25 - 162	5.00 - 32.40
trans-1,2-Dichloroethene	*			20.911	20.811	19.097	20.0	0.5	105%	104%		95%	38 - 155	7.60 - 31.00
1,1-Dichloroethane	*			18.785	18.88	17.713	20.0	0.5	94%	94%		89%	47 - 132	9.40 - 26.40
cis-1,2-Dichloroethene	*			19.488	20.232	18.452	20.0	3.7	97%	101%		92%	-	-
1,1,1-Trichloroethane	*			18.376	18.544	16.660	20.0	0.9	92%	93%		83%	41 - 138	8.20 - 27.60
Carbon Tetrachloride	*			17.987	18.527	16.088	20.0	3.0	90%	93%		80%	43 - 143	8.60 - 28.60
Trichloroethene	W			19.481	19.07	17.880	20.0	2.1	97%	95%		89%	35 - 146	7.00 - 29.20
1,1,2-Trichloroethane	W			19.915	19.583	20.053	20.0	1.7	100%	98%		100%	39 - 136	7.80 - 27.20
Tetrachloroethene	*			17.637	18.829	16.415	20.0	6.5	88%	94%		82%	26 - 162	5.20 - 32.40
1,1,1,2-Tetrachloroethane	*			18.314	17.533	16.920	20.0	4.4	92%	88%		85%	-	-
Chlorobenzene	*			19.02	20.754	17.551	20.0	8.7	95%	104%		88%	1 - 150	0.16 - 30.00
1,1,2,2-Tetrachloroethane	*			22.817	22.364	22.618	20.0	2.0	114%	112%		113%	8 - 184	1.60 - 36.80
2-Chlorotoluene	*			18.084	17.97	15.986	20.0	0.6	90%	90%		80%	-	-
4-Chlorotoluene	*			16.707	16.978	16.326	20.0	1.6	84%	85%		82%	-	-
1,3-Dichlorobenzene	*			17.433	17.065	16.047	20.0	2.1	87%	85%		80%	7 - 187	1.40 - 37.40
1,2-Dichlorobenzene	*			16.638	15.715	14.815	20.0	5.7	83%	79%		74%	0 - 208	0.00 - 41.60

M = Applicable matrices. (* = Soil and Water. w = Water only.)

= Marks a spike recovery out of limits.

If recovery is outside method limit, marked with ***.

If recovery is outside a guideline, marked with ~.

If the sample spike recovery is outside the limit and the control spike is outside the limit also, the control is marked with *** or ~.

Notes on recovery limits:

All spiked analytes must be detected even if low limit is 0.

For analytes not listed in the method, recovery limits of 50-150% will be used as guidelines until limits can be established.

Corrective Actions:

Unacceptable sample spike recovery requires acceptable control spike recovery. If both recoveries are outside limits, corrective action must be taken. One recovery outside limits and the other acceptable, is a warning. Repeated failure requires corrective action.

Recoveries outside guidelines should be compared to historical data available to determine if corrective action is required.

Method 8010 Quality Control Samples

Date Performed: 11/26/96

Reference Standard: V832

Analyte	M	Method Blank	Sample 96-4058-01	Sample Spike	Spike Dup.	Control Spike	Spike Amt	RPD	Spike Recoveries			QC Recovery Range	
									Sample	Dup	# Control	% L - % H	Low - High
Vinyl Chloride	w			18.934	18.194	15.379	20.0	4.0	95%	91%		28 - 163	5.60 - 32.60
Chloroethane	*			15.887	16.059	17.891	20.0	1.1	79%	80%		46 - 137	9.20 - 27.40
1,1-Dichloroethene	*			17.573	17.773	17.127	20.0	1.1	88%	89%		28 - 167	5.60 - 33.40
Dichloromethane	*			18.685	18.774	17.583	20.0	0.5	93%	94%		25 - 162	5.00 - 32.40
trans-1,2-Dichloroethene	*			17.578	20.624	21.135	20.0	15.9	88%	103%		38 - 155	7.60 - 31.00
1,1-Dichloroethane	*			19.601	18.302	19.074	20.0	6.9	98%	92%		47 - 132	9.40 - 26.40
cis-1,2-Dichloroethene	*			20.569	18.868	18.995	20.0	8.6	103%	94%		-	-
1,1,1-Trichloroethane	*			19.451	19.065	18.147	20.0	2.0	97%	95%		41 - 138	8.20 - 27.60
Carbon Tetrachloride	*			19.807	19.25	18.101	20.0	2.9	99%	96%		43 - 143	8.60 - 28.60
Trichloroethene	w			22.269	21.621	19.084	20.0	3.0	111%	108%		35 - 146	7.00 - 29.20
1,1,2-Trichloroethane	w			22.311	23.451	20.830	20.0	5.0	112%	117%		39 - 136	7.80 - 27.20
Tetrachloroethene	*			19.595	19.624	18.384	20.0	0.1	98%	98%		26 - 162	5.20 - 32.40
1,1,1,2-Tetrachloroethane	*			18.985	18.834	18.317	20.0	0.8	95%	94%		-	-
Chlorobenzene	*		6.614	32.611	31.901	18.708	20.0	2.8	130%	126%		1 - 150	0.16 - 30.00
1,1,2,2-Tetrachloroethane	*			22.215	22.98	21.958	20.0	3.4	111%	115%		8 - 184	1.60 - 36.80
2-Chlorotoluene	*			17.424	17.669	17.857	20.0	1.4	87%	88%		-	-
4-Chlorotoluene	*			17.104	16.936	17.091	20.0	1.0	86%	85%		-	-
1,3-Dichlorobenzene	*		0.063	17.327	16.541	16.205	20.0	4.7	86%	82%		7 - 187	1.40 - 37.40
1,2-Dichlorobenzene	*		0.082	14.577	14.405	16.967	20.0	1.2	72%	72%		0 - 208	0.00 - 41.60

M = Applicable matrices. (* = Soil and Water. w = Water only.)

= Marks a spike recovery out of limits.

If recovery is outside method limit, marked with ***.

If recovery is outside a guideline, marked with "~".

If the sample spike recovery is outside the limit and the control spike is outside the limit also, the control is marked with "~~~" or "~~~~".

Notes on recovery limits:

All spiked analytes must be detected even if low limit is 0.

For analytes not listed in the method, recovery limits of 50-150% will be used as guidelines until limits can be established.

Corrective Actions:

Unacceptable sample spike recovery requires acceptable control spike recovery. If both recoveries are outside limits, corrective action must be taken.

One recovery outside limits and the other acceptable, is acceptable.

Recovery outside guidelines should be compared to historical data available to determine if corrective action is required.

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

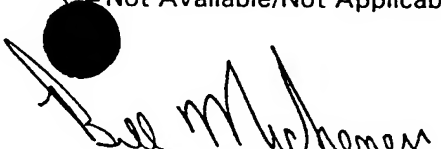
Methane Report Form
Method Blank Report


Method Blank Number	: GB112296	Client Project No.	: 729691.32010
Date Extracted/Prepared	: 11/22/96	Lab Work Order	: 96-4058
Date Analyzed	: 11/22/96	Dilution Factor	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS1122002

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
/ = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: W79	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4058-03	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Dilution Factor	: 1.00
Date Received	: 11/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122011

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

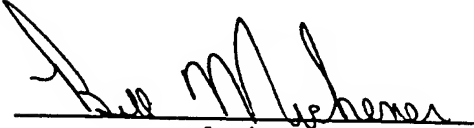
Temperature	: 76.3 F
Amount Injected	: 0.5 ml
Total Volume of Sample	: 43 ml
Head space created	: 4 ml
Methane Area	: 0 ug


Saturation	Meth
Concentration	
Concentration	Meth
in Head Space	

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: W82	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4058-04	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Dilution Factor	: 1.00
Date Received	: 11/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122012

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 75.9 F	Saturation	Meth	0
Volume Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0
Head space created	: 4 ml	in Head Space		
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers


E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

*A = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPH	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4058-05	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Dilution Factor	: 1.00
Date Received	: 11/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122013

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 75.8 F	Saturation Meth	
Amount Injected	: 0.5 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	
Head space created	: 4 ml	in Head Space	
Methane Area	: 0 ug		

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

B. M. Mchen
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPL	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4058-06	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Dilution Factor	: 10.00
Date Received	: 11/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122014

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.21	0.02

Temperature	: 75.8 F	Saturation	Meth	0.050843483
Volume Injected	: 0.05 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.159059193
Head space created	: 4 ml	in Head Space		
Methane Area	: 118.234 ug			

Atomic weight(Methane) : 16 g

Qualifiers

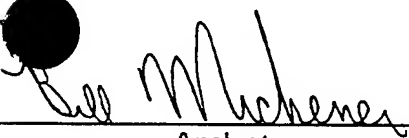
E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPL	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4058-06Dup	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Dilution Factor	: 10.00
Date Received	: 11/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122015

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.21	0.02

Temperature	: 75.8 F	Saturation Meth	: 0.050
Amount Injected	: 0.05 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	: 0.1577408
Head space created	: 4 ml	in Head Space	
Methane Area	: 117.254 ug		

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Bee Michener
Analyst

K. Hillman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: W18	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4058-07	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Dilution Factor	: 1.00
Date Received	: 11/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122016

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.110	0.002

Temperature	: 75.7 F	Saturation Meth	: 0.02669457
Amount Injected	: 0.5 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	: 0.083527131
Head space created	: 4 ml	in Head Space	
Methane Area	: 620.769 ug		

Atomic weight(Methane) : 16 g

Qualifiers


E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

A = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPK	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4058-08	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Dilution Factor	: 10.00
Date Received	: 11/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122017

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.22	0.02

Temperature	: 75.8 F	Saturation	Meth	0.052
Amount Injected	: 0.05 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.16358744
Head space created	: 4 ml	in Head Space		
Methane Area	: 121.6 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Bob Michener
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPI	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4058-09	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	Dilution Factor	: 10.00
Date Received	: 11/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122019

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.26	0.02

Temperature	: 76.3 F	Saturation	Meth	0.062608945
Volume Injected	: 0.05 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.195683554
Head space created	: 4 ml	in Head Space		
Methane Area	: 145.594 ug			

Atomic weight(Methane) : 16 g

Qualifiers

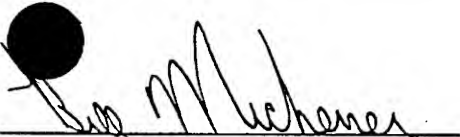
E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

NA = Not Available/Not Applicable.


Analyst


Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane Gas Matrix Spike / Matrix Spike Duplicate Report

Client Sample No.	: LF6-MPH	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-05	Lab Work Order	: 96-4058
Date Sampled	: 11/15/96	EPA Method No.	: RSKSOP-175M
Date Received	: 11/16/96	Matrix	: Water
Date Prepared	: 11/22/96	Method Blank	: GB112296
Date Analyzed	: 11/22/96	Lab File No's.	: GAS1122020,021
E.A. MS/MSD Spike Source No.	: 1886		

Compound	Spike Added (ug)	Sample Concentration (ug)	MS Concentration (ug)	MS %REC	QC Limits %REC
Methane Gas	500	0	426	85	47-88

Compound	Spike Added (ug)	MSD Concentration (ug)	MSD %REC	RPD	QC Limits RPD	QC Limits %REC
Methane Gas	500	430	86	0.9	0-16.4	47-88

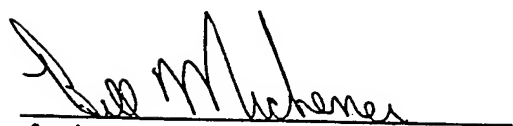
RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes

* = Values outside of QC limits.

NA = Not analyzed/not available

Note: The Spike was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.


Analyst


Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane LCS Report Form

LCS No. : LCS112296 EPA Method No. : RSKSOP-175M
Date Prepared : 11/22/96 Matrix : Water
Date Analyzed : 11/22/96 Method Blank : GB112296
E.A. LCS Source No. : 1886 Lab File No. : GAS1122009

Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	417	83	64-90


Spike Recovery: 0 out of (1) outside limits.


Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes

* = Values outside of QC limits.

NA = Not analyzed/not available.


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

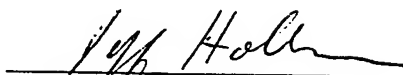
Date Sampled : 11/15/96
Date Received : 11/16/96
Date Prepared : 11/16/96
Date Analyzed : 11/16/96


Client Project ID. : 729691.32010
Lab Project Number : 96-4058
Method : EPA 300.0
Detection Limit : 0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride mg/L	Dilution Factor
96-4058-03	W79	Water	3.7	1
96-4058-03 Duplicate	W79 Duplicate	Water	3.7	1
96-4058-04	W82	Water	5.5	1
96-4058-05	LF6-MPH	Water	3.9	1
96-4058-06	LF6-MPL	Water	11.3	1
96-4058-07	W18	Water	16.8	1
96-4058-08	LF6-MPK	Water	18.9	1
96-4058-09	LF6-MPI	Water	51.2	10
Method Blank	(11/16/96)	Water	<0.25	1

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-4058-03	W79 Matrix Spike	10.0	3.7	14.1	103
96-4058-03	W79 Matrix Spike Dup	10.0	3.7	14.4	106
MS/MSD RPD					2.9


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/15/96
Date Received : 11/16/96
Date Prepared : 11/16/96
Date Analyzed : 11/16/96

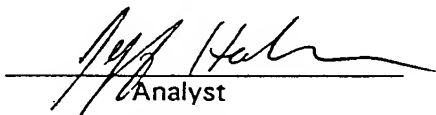
Client Project ID. : 729691.32010
Lab Project Number : 96-4058
Method : EPA 300.0
Detection Limit : 0.076 mg/L

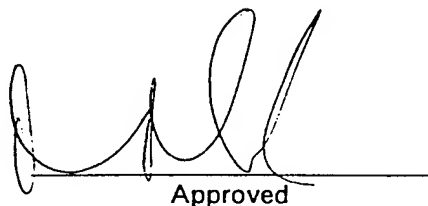
Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N mg/L	Dilution Factor
96-4058-03	W79	Water	<0.076	1
96-4058-03 Duplicate	W79 Duplicate	Water	<0.076	1
96-4058-04	W82	Water	<0.076	1
96-4058-05	LF6-MPH	Water	<0.076	1
96-4058-06	LF6-MPL	Water	<0.076	1
96-4058-07	W18	Water	<0.076	1
96-4058-08	LF6-MPK	Water	<0.076	1
96-4058-09	LF6-MPI	Water	<0.076	1
Method Blank	(11/16/96)	Water	<0.076	1

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-4058	W79 Matrix Spike	10.0	<0.25	9.7	97
96-4058	W79 Matrix Spike Dup	10.0	<0.25	9.6	96
MS/MSD RPD					0.7

* = Quality assurance results reported as Nitrite (NO₂).


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/15/96
Date Received : 11/16/96
Date Prepared : 11/16/96
Date Analyzed : 11/16/96


Client Project ID. : 729691.32010
Lab Project Number : 96-4058
Method : EPA 300.0
Detection Limit : 0.056 mg/L

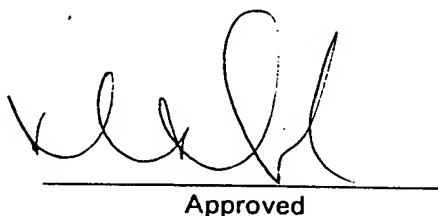
Evergreen Sample #	Client Sample ID.	Matrix	Nitrate-N mg/L	Dilution Factor
96-4058-03	W79	Water	1.4	1
96-4058-03 Duplicate	W79 Duplicate	Water	1.4	1
96-4058-04	W82	Water	1.9	1
96-4058-05	LF6-MPH	Water	0.61	1
96-4058-06	LF6-MPL	Water	<0.056	1
96-4058-07	W18	Water	<0.056	1
96-4058-08	LF6-MPK	Water	<0.056	1
96-4058-09	LF6-MPI	Water	<0.056	1
Method Blank	(11/16/96)	Water	<0.056	1

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-4058-03	W79 Matrix Spike	10.0	6.2	16.0	98
96-4058-03	W79 Matrix Spike Dup	10.0	6.2	16.0	98
MS/MSD RPD					0.6

* = Quality assurance results reported as Nitrate (NO₃).


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/15/96
Date Received : 11/16/96
Date Prepared : 11/16/96
Date Analyzed : 11/16/96

Client Project ID. : 729691.32010
Lab Project Number : 96-4058
Method : EPA 300.0
Detection Limit : 0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Sulfate mg/L	Dilution Factor
96-4058-03	W79	Water	1.3	1
96-4058-03 Duplicate	W79 Duplicate	Water	1.3	1
96-4058-04	W82	Water	1.5	1
96-4058-05	LF6-MPH	Water	14.9	1
96-4058-06	LF6-MPL	Water	5.6	1
96-4058-07	W18	Water	8.9	1
96-4058-08	LF6-MPK	Water	3.7	1
96-4058-09	LF6-MPI	Water	1.4	1

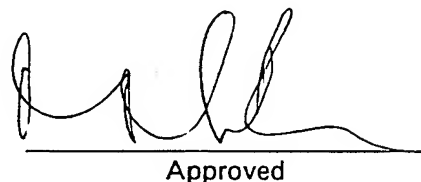
Method Blank	(11/16/96)	Water	<0.25	1
--------------	------------	-------	-------	---

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-4058-03	W79 Matrix Spike	10.0	1.3	10.5	92
96-4058-03	W79 Matrix Spike Dup	10.0	1.3	10.4	91

MS/MSD RPD	1.4
------------	-----


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Total Recoverable Petroleum Hydrocarbons

Date Sampled : 11/15/96
Date Received : 11/16/96
Date Prepared : 11/19/96
Date Analyzed : 11/19/96

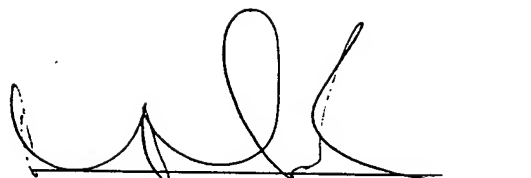
Client Project ID. : 729691.32010
Lab Project Number : 96-4058
Method : EPA 418.1

<u>Evergreen Sample #</u>	<u>Client Sample ID.</u>	<u>Matrix</u>	<u>TRPH</u>	<u>Units</u>
96-4058-01	LF-06-MPF-(4-8)'	Soil	760	mg/Kg
96-4058-02	LF06-MPF-(8-10)'	Soil	<3.9	mg/Kg
96-4058-02 Duplicate	LF06-MPF-(8-10)' Duplicate	Soil	<3.9	mg/Kg

Method Blank (11/19/96) Subtracted	4.9	mg/Kg
------------------------------------	-----	-------

Results calculated on a dry weight basis.


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Total Organic Carbon

Date Sampled : 11/15/96
Date Received : 11/16/96
Date Prepared : 11/25/96
Date Analyzed : 11/25/96

Client Project ID. : 729691.32010
Lab Project Number : 96-4058
Method : EPA 415.1
Detection Limit : 1.0 mg C/L


Evergreen Sample #	Client Sample ID.	Matrix	TOC mg C/L	Dilution Factor
96-4058-08	LF6-MPK	Water	5.6	1
96-4058-08 Duplicate	LF6-MPK Duplicate	Water	5.9	1
96-4058-09	LF6-MPI	Water	<1.0	1

Method Blank (11/25/96)


<1.0

Quality Assurance

		<u>Spike Amount</u> (mgC/L)	<u>Sample Result</u> (mgC/L)	<u>Spike Result</u> (mgC/L)	<u>% Recovery</u>
96-4058-08	LF6-MPK Matrix Spike	10.0	5.6	16.6	110
96-4058	LF6-MPK Matrix Spike Dup	10.0	5.6	16.2	105
MS/MSD RPD					3.8



Analyst



Approved

WORK ORDER Summary

20-Nov-96

Report To: Dave Moutoux

Client Project ID: 729691.32010

Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-4064-01K	LF6-MPN	Anions by IC Cl,NO2,NO3,SO4		Water	CR3	17-Nov-96	18-Nov-96	03-Dec-96	19-Nov-96
96-4064-02K	LF6-MPC(S)	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	19-Nov-96
96-4064-03K	LF6-MPC(D)	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	19-Nov-96
96-4064-04K	LF6-MPJ	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	19-Nov-96
96-4064-05K	LF6-MPA(S)	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	19-Nov-96
96-4064-06K	LF6-MPA(D)	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	19-Nov-96
96-4064-07K	LF06-MW19	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	19-Nov-96
96-4064-08K	LF06-MPR	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	19-Nov-96
96-4064-09K	LF06-MPD(D)	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	19-Nov-96
96-4064-10K	LF06-MPF(D)	Anions by IC Cl,NO2,NO3,SO4						03-Dec-96	19-Nov-96
96-4064-01D	LF6-MPN	BTEX Parsons			2			03-Dec-96	01-Dec-96
96-4064-02D	LF6-MPC(S)	BTEX Parsons						03-Dec-96	01-Dec-96
96-4064-03D	LF6-MPC(D)	BTEX Parsons						03-Dec-96	01-Dec-96
96-4064-04D	LF6-MPJ	BTEX Parsons						03-Dec-96	01-Dec-96
96-4064-05D	LF6-MPA(S)	BTEX Parsons						03-Dec-96	01-Dec-96
96-4064-06D	LF6-MPA(D)	BTEX Parsons						03-Dec-96	01-Dec-96

= Special list. See sample comments or test information.

HT = Holding Time expiration date.

Evergreen Analytical, Inc.

96-4064

WORK ORDER Summary

20-Nov-96

Report To: Dave Moutoux

Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.32010

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-4064-07D	LF06-MW19	BTEX Parsons		Water	2	17-Nov-96	18-Nov-96	03-Dec-96	01-Dec-96
96-4064-08D	LF06-MPR	BTEX Parsons						03-Dec-96	01-Dec-96
96-4064-09D	LF06-MPD(D)	BTEX Parsons						03-Dec-96	01-Dec-96
96-4064-10D	LF06-MPF(D)	BTEX Parsons						03-Dec-96	01-Dec-96
96-4064-01H	LF6-MPN	Methane						03-Dec-96	01-Dec-96
96-4064-02H	LF6-MPC(S)	Methane						03-Dec-96	01-Dec-96
96-4064-03H	LF6-MPC(D)	Methane						03-Dec-96	01-Dec-96
96-4064-04H	LF6-MPJ	Methane						03-Dec-96	01-Dec-96
96-4064-05H	LF6-MPA(S)	Methane						03-Dec-96	01-Dec-96
96-4064-06H	LF6-MPA(D)	Methane						03-Dec-96	01-Dec-96
96-4064-07H	LF06-MW19	Methane						03-Dec-96	01-Dec-96
96-4064-08H	LF06-MPR	Methane						03-Dec-96	01-Dec-96
96-4064-09H	LF06-MPD(D)	Methane						03-Dec-96	01-Dec-96
96-4064-10H	LF06-MPF(D)	Methane						03-Dec-96	01-Dec-96
96-4064-01A	LF6-MPN	Purgeable Halocarbons 8010						03-Dec-96	01-Dec-96
96-4064-02A	LF6-MPC(S)	Purgeable Halocarbons 8010						03-Dec-96	01-Dec-96
96-4064-03A	LF6-MPC(D)	Purgeable Halocarbons 8010						03-Dec-96	01-Dec-96
96-4064-04A	LF6-MPJ	Purgeable Halocarbons 8010						03-Dec-96	01-Dec-96
96-4064-05A	LF6-MPA(S)	Purgeable Halocarbons 8010						03-Dec-96	01-Dec-96
96-4064-06A	LF6-MPA(D)	Purgeable Halocarbons 8010						03-Dec-96	01-Dec-96
96-4064-07A	LF06-MW19	Purgeable Halocarbons 8010						03-Dec-96	01-Dec-96
96-4064-08A	LF06-MPR	Purgeable Halocarbons 8010						03-Dec-96	01-Dec-96
96-4064-09A	LF06-MPD(D)	Purgeable Halocarbons 8010						03-Dec-96	01-Dec-96

= Sp... See sample comments or test information.
HT = ... time expiration date.

WORK ORDER SUMMARY

21-Nov-96

Report To: Dave Moutoux

Client Project ID: 729691.32010

Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-4064-10A	LF06-MPF(D)	Purgeable Halocarbons 8010		Water	9	17-Nov-96	18-Nov-96	03-Dec-96	01-Dec-96
96-4064-11A	Trip Blank #7	Purgeable Halocarbons 8010							
96-4064-01D	LF6-MPN	TVH (Gasoline)	2					03-Dec-96	01-Dec-96
96-4064-02D	LF6-MPC(S)	TVH (Gasoline)						03-Dec-96	01-Dec-96
96-4064-03D	LF6-MPC(D)	TVH (Gasoline)						03-Dec-96	01-Dec-96
96-4064-04D	LF6-MPJ	TVH (Gasoline)						03-Dec-96	01-Dec-96
96-4064-05D	LF6-MPA(S)	TVH (Gasoline)						03-Dec-96	01-Dec-96
96-4064-06D	LF6-MPA(D)	TVH (Gasoline)						03-Dec-96	01-Dec-96
96-4064-07D	LF06-MW19	TVH (Gasoline)						03-Dec-96	01-Dec-96
96-4064-08D	LF06-MPR	TVH (Gasoline)						03-Dec-96	01-Dec-96
96-4064-09D	LF06-MPD(D)	TVH (Gasoline)						03-Dec-96	01-Dec-96
96-4064-10D	LF06-MPF(D)	TVH (Gasoline)						03-Dec-96	01-Dec-96

CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

2 of 2

COMPANY Parsons ES
ADDRESS 1700 Broadway, Ste 900
CITY Denver STATE CO ZIP 80290
PHONE# (303) 851-8100 FAX # (303) 851-8208
FAX RESULTS Y / N

CLIENT CONTACT (print) Jenny Henderson
CLIENT PROJ. I.D. 729691.32010
EAL QUOTE # P.O.# 729691.32010
TURNAROUND REQUIRED* ☒ STD (2 wks) ☐ UST
*expedited turnaround subject to additional fee

Sampler Name: Rob Noyes / Bruce Henry
(signature) [Signature]
(print) Rob Noyes / Bruce Henry

Please PRINT
all information:

CLIENT SAMPLE IDENTIFICATION TRIP BLANK #7 DATE SAMPLED 11/17/96 TIME -

MATRIX		ANALYSIS REQUESTED															EAL use only Do not write in shaded area	
No. of Containers	1	Water-Drinking/Discharge/Ground (circle)																
Soil / Solid / Air / Gas		Oil / Sludge / Multi-phase																
TCLP VOA/BNA/Pest/Herb/Metals (circle)		VOA 8260/624/524.2 (circle)																
BNA 8270/625 (circle)		Pesticides 8080/608 (circle)																
Pest/PCBs 8080/608/508 (circle)		PCB Screen																
Herbicides 8150/515 (circle)		BTEX 8020/602 (circle)/MTBE (circle)																
TPH 8015mod. (Gasoline)		TEPH 8015mod. (Diesel)																
Total Metals-DW / NPDES / SW846 (circle & list metals below)		Dissolved Metals - DW / SW846 (circle & list metals below)																
Oil & Grease 413.1		TRPH 418.1																

Loc YDU
Cont

Instructions:

Relinquished by: (Signature) [Signature] Date/Time 11/18/96 5:30AM
Received by: (Signature) [Signature] Date/Time 11/18/96 11:50



ATLANTIC SOUTHEAST AIRLINES, INC.

SHIPPERS DECLARATION OF NON-INFECTIOUS SUBSTANCES

The United States Department of Transportation (DOT) has adopted by reference the IATA/ICAO (49 CFR) Dangerous Goods Regulations.

These regulations address infectious substances as follows:

Infectious Substances (Division 6.2)

3.6.6 "Infectious substances" are defined as those substances containing viable micro-organisms or their toxins which are known, or suspected, to cause disease in animals or humans.

NOTE 1: "Biological products" and "Diagnostic specimens" are not considered to be dangerous goods provided they do not contain, or are reasonably believed not to contain, an infectious substance, or do not contain any other dangerous substance.

NOTE 2: Any substance containing acquired immune deficiency syndrome virus (AIDS), suspected of containing AIDS, or being transported for diagnostic analysis for AIDS is considered as an infectious substance for the purposes of these Regulations.

"Diagnostic specimens" are any human or animal material including, but not limited to, excreta, secretions, blood and its components, tissue and tissue fluids, being shipped for purposes of diagnosis, but excluding live infected animals.

0108
nd 0108
I certify that this shipment is not of an infectious nature nor is it being transported for the testing of infectious substances as defined in this declaration.

DATE 11/18/96

NAME Rob Nagel

(Please Print)

COMPANY NAME Parsons Engineering Science

SIGNATURE Rob Nagel

AIR WAYBILL NUMBER 862 GTR 62973945

DISTRIBUTION: ORIGINAL - Origin Station copy of Air Waybill
COPY 2 - Attached to Delivery Receipt
COPY 3 - Shipper.

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB2112196 Client Project Number : 729691.32010
Date Prepared : 11/21/96 Lab Work Order : 96-4064
Dilution Factor : 1.0 Matrix : WATER
Lab File Number : TVB21120028

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/21/96	U	0.1	mg/L
Benzene	71-43-2	11/21/96	U	0.4	ug/L
Toluene	108-88-3	11/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/21/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/21/96	U	0.5	ug/L
FID Surrogate Recovery: 81% 70%-126% (Limits)					
Surrogate Recovery: 91% 76%-127% (Limits)					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB211.2296 Client Project Number : 729691.32010
Date Prepared : 11/22/96 Lab Work Order : 96-4064
Dilution Factor : 1.0 Matrix : WATER
Lab File Number : TVB21120061

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/22/96	U	0.1	mg/L
Benzene	71-43-2	11/22/96	U	0.4	ug/L
Toluene	108-88-3	11/22/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/22/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/22/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/22/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/22/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/22/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/22/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/22/96	U	0.5	ug/L
FID Surrogate Recovery: 87% 70%-126% (Lir					
PID Surrogate Recovery: 94% 76%-127% (L					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Bliska
Analyst

K. Hillman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPN Client Project Number : 729691.32010
Lab Sample Number : 96-4064-01 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Matrix : WATER
Date Received : 11/18/96 Lab File Number(s) : TVB21120036
Date Prepared : 11/21/96 Method Blank : MB2112196
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/21/96	U	0.1	mg/L
Benzene	71-43-2	11/21/96	1.6	0.4	ug/L
Toluene	108-88-3	11/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/21/96	35	0.4	ug/L
Ethyl Benzene	100-41-4	11/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/21/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/21/96	U	0.5	ug/L
Surrogate Recovery:		107%		70%-126%	(Limits)
Surrogate Recovery:		106%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.

RL = Reporting Limit.

NA = Not Available/Not Applicable.

PID = Photoionization detector.

FID = Flame ionization detector.

TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPC(S) Client Project Number : 729691.32010
Lab Sample Number : 96-4064-02 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Matrix : WATER
Date Received : 11/18/96 Lab File Number(s) : TVB21120037
Date Prepared : 11/21/96 Method Blank : MB2112196
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	---	11/21/96	U	0.1	mg/L
Benzene	71-43-2	11/21/96	1.8	0.4	ug/L
Toluene	108-88-3	11/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/21/96	21	0.4	ug/L
Ethyl Benzene	100-41-4	11/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/21/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/21/96	U	0.5	ug/l
FID Surrogate Recovery:		95%		70%-126%	(Limit)
PID Surrogate Recovery:		105%		76%-127%	(Limit)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Halman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPC(D) Client Project Number : 729691.32010
Lab Sample Number : 96-4064-03 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Matrix : WATER
Date Received : 11/18/96 Lab File Number(s) : TVB21120062
Date Prepared : 11/22/96 Method Blank : MB2112296
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/22/96	U	0.1	mg/L
Benzene	71-43-2	11/22/96	1.8	0.4	ug/L
Toluene	108-88-3	11/22/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/22/96	5.0	0.4	ug/L
Ethyl Benzene	100-41-4	11/22/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/22/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/22/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/22/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/22/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/22/96	U	0.5	ug/L
Surrogate Recovery:		96%	70%-126% (Limits)		
Surrogate Recovery:		98%	76%-127% (Limits)		

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPJ Client Project Number : 729691.32010
Lab Sample Number : 96-4064-04 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Matrix : WATER
Date Received : 11/18/96 Lab File Number(s) : TVB21120039
Date Prepared : 11/21/96 Method Blank : MB2112196
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/21/96	U	0.1	mg/L
Benzene	71-43-2	11/21/96	U	0.4	ug/L
Toluene	108-88-3	11/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/21/96	1.1	0.4	ug/L
Ethyl Benzene	100-41-4	11/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/21/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/21/96	U	0.5	ug"
FID Surrogate Recovery:		93%		70%-126%	(Limits)
PID Surrogate Recovery:		102%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hallman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPA(S) Client Project Number : 729691.32010
Lab Sample Number : 96-4064-05 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Matrix : WATER
Date Received : 11/18/96 Lab File Number(s) : TVB21120063
Date Prepared : 11/22/96 Method Blank : MB2112296
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/22/96	U	0.1	mg/L
Benzene	71-43-2	11/22/96	U	0.4	ug/L
Toluene	108-88-3	11/22/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/22/96	0.9	0.4	ug/L
Ethyl Benzene	100-41-4	11/22/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/22/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/22/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/22/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/22/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/22/96	4.2	0.5	ug/L
Surrogate Recovery:		86%		70%-126%	(Limits)
Surrogate Recovery:		95%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF6-MPA(D) Client Project Number : 729691.32010
Lab Sample Number : 96-4064-06 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Matrix : WATER
Date Received : 11/18/96 Lab File Number(s) : TVB21120070
Date Prepared : 11/22/96 Method Blank : MB2112296
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0


Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/22/96	U	0.1	mg/L
Benzene	71-43-2	11/22/96	3.0	0.4	ug/L
Toluene	108-88-3	11/22/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/22/96	32	0.4	ug/L
Ethyl Benzene	100-41-4	11/22/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/22/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/22/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/22/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/22/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/22/96	0.9	0.5	ug/L
FID Surrogate Recovery:		99%		70%-126%	(%)
PID Surrogate Recovery:		101%		76%-127%	(%)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF06-MW19 Client Project Number : 729691.32010
Lab Sample Number : 96-4064-07 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Matrix : WATER
Date Received : 11/18/96 Lab File Number(s) : TVB21120043
Date Prepared : 11/21/96 Method Blank : MB2112196
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/21/96	U	0.1	mg/L
Benzene	71-43-2	11/21/96	U	0.4	ug/L
Toluene	108-88-3	11/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/21/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/21/96	U	0.5	ug/L
Surrogate Recovery: 96% 70%-126% (Limits)					
PID Surrogate Recovery: 100% 76%-127% (Limits)					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF06-MPR Client Project Number : 729691.32010
Lab Sample Number : 96-4064-08 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Matrix : WATER
Date Received : 11/18/96 Lab File Number(s) : TVB21120067
Date Prepared : 11/22/96 Method Blank : MB2112296
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0


Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/22/96	U	0.1	mg/L
Benzene	71-43-2	11/22/96	U	0.4	ug/L
Toluene	108-88-3	11/22/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/22/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/22/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/22/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/22/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/22/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/22/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/22/96	U	0.5	ug
FID Surrogate Recovery:		93%		70%-126%	(L)
PID Surrogate Recovery:		98%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF06-MPD(D) Client Project Number : 729691.32010
Lab Sample Number : 96-4064-09 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Matrix : WATER
Date Received : 11/18/96 Lab File Number(s) : TVB21120045
Date Prepared : 11/21/96 Method Blank : MB2112196
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/21/96	U	0.1	mg/L
Benzene	71-43-2	11/21/96	2.2	0.4	ug/L
Toluene	108-88-3	11/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/21/96	22	0.4	ug/L
Ethyl Benzene	100-41-4	11/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/21/96	0.5	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/21/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/21/96	1.7	0.5	ug/L
Surrogate Recovery: 92% 70%-126% (Limits)					
PID Surrogate Recovery: 98% 76%-127% (Limits)					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF06-MPF(D) Client Project Number : 729691.32010
Lab Sample Number : 96-4064-10 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Matrix : WATER
Date Received : 11/18/96 Lab File Number(s) : TVB21120053
Date Prepared : 11/21/96 Method Blank : MB2112196
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/22/96	U	0.1	mg/L
Benzene	71-43-2	11/22/96	2.1	0.4	ug/L
Toluene	108-88-3	11/22/96	3.2	0.4	ug/L
Chlorobenzene	108-90-7	11/22/96	7.9	0.4	ug/L
Ethyl Benzene	100-41-4	11/22/96	0.5	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/22/96	1.3	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/22/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/22/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/22/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/22/96	U	0.5	ug/L
FID Surrogate Recovery: 96% 70%-126% (Li					
PID Surrogate Recovery: 97% 76%-127% (Li					

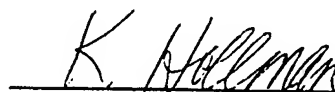
Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: LF6-MPN	Client Project No.	: 72691.32010
Lab Sample No.	: 96-4064-01	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 11/18/96	Matrix	: WATER
Date Prepared	: 11/21/96	Lab File Number(s)	: TVB21120054,55
Date Analyzed	: 11/22/96	Method Blank	: MB2112196
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#) Limits
					%REC
Gasoline	2.00	0.00	1.60	80.1%	60 - 128
Surrogate **	---	---	---	107%	70 - 126

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#) Limits	
					RPD	%REC
Gasoline	2.00	2.04	102.2%	24.3	44.1	60 - 128
Surrogate **	---	---	115%	NA	NA	70 - 126

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:

NA = Not analyzed/not applicable.

* = Values outside of QC limits.

** = 1,2,4-Trichlorobenzene

= Limits established 10/1/96, MAB

Comments:

M. Bliska

Analyst

K. Hollman

Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: LF6-MPC(S)	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4064-02	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	EPA Method No.	: 602/8020
Date Received	: 11/18/96	Matrix	: WATER
Date Prepared	: 11/21/96	Lab File Number(s)	: TVB21120056,57
Date Analyzed	: 11/22/96	Method Blank	: MB2112196
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L)		Comments
			MS	MSD	
Benzene	20.0	1.8	23.5	23.4	
Toluene	20.0	0.0	20.9	20.8	
Chlorobenzene	20.0	21.0	41.1	41.0	
Ethylbenzene	20.0	0.0	21.7	21.7	
m,p-Xylene	20.0	0.0	21.4	21.3	
o-Xylene	20.0	0.0	20.8	20.8	
1,3,5-TMB	20.0	0.0	20.1	20.0	
1,2,4-TMB	20.0	0.0	19.1	19.0	
1,2,3-TMB	20.0	0.0	21.4	21.4	
1,2,3,4-TeMB	20.0	0.0	21.3	21.2	
Surrogate	100.0	105%	101%	100%	% RECOVERY

Compound	MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits	
				RPD	%REC
Benzene	108.5	108.0	0.5	17	61 - 129
Toluene	104.5	104.0	0.5	18	61 - 127
Chlorobenzene	100.5	100.0	0.5	16	68 - 122
Ethylbenzene	108.5	108.5	0.0	18	63 - 126
m,p-Xylene	107.0	106.5	0.5	18	60 - 130
o-Xylene	104.0	104.0	0.0	18	62 - 128
1,3,5-TMB	100.5	100.0	0.5	18	69 - 117
1,2,4-TMB	95.5	95.0	0.5	23	69 - 119
1,2,3-TMB	107.0	107.0	0.0	16	71 - 118
1,2,3,4-TeMB	106.5	106.0	0.5	27	67 - 125
Surrogate	101.0	100.0	NA	NA	76 - 127

= Limits established 10/15/96, KSH

* = Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments: _____

M. Blecha
Analyst

K. Hallman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: <u>LCS2112196-GAS</u>	Matrix	: <u>WATER</u>
Date Prepared	: <u>11/21/96</u>	Method Numbers	: <u>EPA 5030/8015 Modified</u>
Date Analyzed	: <u>11/21/96</u>	Instrument Name	: <u>TVHBTEX2</u>
Lab File Number(s)	: <u>TVB21120049</u>		

<u>Compound Name</u>	<u>Theoretical Concentration (mg/L)</u>	<u>LCS Concentration (mg/L)</u>	<u>LCS % Recovery</u>	<u>QC Limit % Recovery</u>
Gasoline	2.00	2.25	112.7	81 - 128

Surrogate Recovery:	112%	70 - 126
---------------------	------	----------

QUALIFIERS

B = TVH as Gasoline found in blank also.

E = Extrapolated value. Value exceeds calibration range.

NA = Not Available/Not Applicable.

** = Limits established 10/1/96 for TVHBTEX2. MAB

M. H. H. H.
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 8010 Chlorinated VOC's Method Blank Report

Method Blank : RB112596 Client Project No. : 729691.32010
Date Prepared : 11/25/96 Lab Project No. : 96-4064
Date Analyzed : 11/25/96 Lab File No. : HALL1125\004F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	U	

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 85% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Method Blank Report

Method Blank : RB112696 Client Project No. : 729691.32010
Date Prepared : 11/26/96 Lab Project No. : 96-4064
Date Analyzed : 11/26/96 Lab File No. : HALL1126\005F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 84% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

PAR8010W.XLS; 12/2/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : LF6-MPN Client Project No. : 729691.32010
Lab Sample No. : 96-4064-01 Lab Project No. : 96-4064
Date Sampled : 11/17/96 Matrix : Water
Date Received : 11/18/96 Lab File No. : HALL1125\009F0101
Date Prepared : 11/25/96 Method Blank : RB112596
Date Analyzed : 11/25/96 Dilution Factor : 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	2.4 J	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	7.2	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	23	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	11	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 100% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4064.XLS; 12/5/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6-MPC(S)	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4064-02	Lab Project No.	: 96-4064
Date Sampled	: 11/17/96	Matrix	: Water
Date Received	: 11/18/96	Lab File No.	: HALL1125\010F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	2 J	0.4
Chloroethane	75-00-3	1.3 J	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	1.2	0.4
cis-1,2-Dichloroethene	156-59-4	0.78 J	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	14	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	0.87 J	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 95% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4064.XLS; 12/5/96

QUANT REPORT

Page 1

Operator ID: KIM
Output File: ^V2960::Q1
Data File: >V2960::V2
Name: 96-4064-02 ;;;KL
Misc: 5;W;0;1;W;0;11/27/96;0

Quant Rev: 7 Quant Time: 961127 16:58
 Injected at: 961127 16:33
Dilution Factor: 1.00000
Instrument ID: VOA 1

ID File: ID_824::QT

Title: ID FILE FOR APPENDIX NINE VOAs METHOD 8260A(8240)

Last Calibration: 961125 12:35

Last Qcal Date: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	q
1)	*BROMOCHLOROMETHANE(INT STD)	6.14	584	35312	50.00	UG/L	82
4)	BROMOMETHANE	1.30	95	926	1.39	UG/L	100
5)	VINYL CHLORIDE	1.01	66	2722	2.06	UG/L	100
6)	CHLOROETHANE	1.37	103	1096M	2.02	UG/L	100
17)	1,1 DICHLOROETHANE	4.14	382	6910	2.49	UG/L	100
19)	CIS 1,2-DICHLOROETHENE	5.61	530	1740M	1.34	UG/L	37
23)	1,2 DICHLOROETHANE-D4(SUR STD)	7.44	715	85889	52.50	UG/L	100
24)	*1,4 DIFLUOROBENZENE(INT STD)	8.60	832	173223	50.00	UG/L	100
46)	*CHLOROBENZENE-D5(INTERNAL STD)	14.41	1418	146366	50.00	UG/L	100
53)	TOLUENE-D8(SURROGATE STD)	11.50	1124	184330	49.35	UG/L	100
55)	CHLOROBENZENE	14.46	1423	65641	21.81	UG/L	100
58)	BROMOFLUOROBENZENE(SURR STD)	17.02	1681	100170	49.13	UG/L	100
63)	1,2-DICHLOROBENZENE	20.33	2015	3486	1.43	UG/L	69
64)	1,4-DICHLOROBENZENE	19.56	1937	26122	9.79	UG/L	99

* Compound is ISTD

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6-MPC(D)	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4064-03	Lab Project No.	: 96-4064
Date Sampled	: 11/17/96	Matrix	: Water
Date Received	: 11/18/96	Lab File No.	: HALL1125\011F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	3	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	2.3	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	2.3	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 88% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

PAR8010W.XLS; 12/2/96

QUANT REPORT

Page 1

Operator ID: KIM
Output File: ^V2961::Q1
Data File: >V2961::V2
Name: 96-4064-03 ;:KL
Misc: S;W;0;1;W;0;11/27/96;0

Quant Rev: 7 Quant Time: 961127 17:25
 Injected at: 961127 17:00
Dilution Factor: 1.00000
Instrument ID: VOA 1

ID File: ID_824::QT

Title: ID FILE FOR APPENDIX NINE VOAs METHOD 8260A(8240)

Last Calibration: 961125 12:35

Last Qcal Date: <none>

Compound	R.T.	Scan#	Area	Conc	Units	q
1) *BROMOCHLOROMETHANE(INT STD)	6.12	582	29917M	50.00	UG/L	77
4) BROMOMETHANE	1.30	95	911	1.61	UG/L	100
5) VINYL CHLORIDE	.99	64	3691	3.30	UG/L	100
17) 1,1 DICHLOROETHANE	4.13	381	4262	1.81	UG/L	100
19) CIS 1,2-DICHLOROETHENE	5.63	532	3194M	2.90	UG/L	76
23) 1,2 DICHLOROETHANE-D4(SUR STD)	7.45	716	72236	52.11	UG/L	100
24) *1,4 DIFLUOROBENZENE(INT STD)	8.59	831	146335	50.00	UG/L	100
46) *CHLOROBENZENE-D5(INTERNAL STD)	14.38	1415	124411	50.00	UG/L	100
53) TOLUENE-D8(SURROGATE STD)	11.45	1119	155753	49.06	UG/L	100
55) CHLOROBENZENE	14.43	1420	13653	5.34	UG/L	100
58) BROMOFLUOROBENZENE(SURR STD)	17.01	1680	84559	48.80	UG/L	100
64) 1,4-DICHLOROBENZENE	19.57	1939	19287	8.51	UG/L	96

* Compound is ISTD

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6-MPJ	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4064-04	Lab Project No.	: 96-4064
Date Sampled	: 11/17/96	Matrix	: Water
Date Received	: 11/18/96	Lab File No.	: HALL1125\012F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	2.1 J	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 86% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4064.XLS; 12/5/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6-MPA(S)	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4064-05	Lab Project No.	: 96-4064
Date Sampled	: 11/17/96	Matrix	: Water
Date Received	: 11/18/96	Lab File No.	: HALL1125\013F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 83% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

PAR8010W.XLS; 12/2/96

QUANT REPORT

Page 1

Operator ID: KIM
Output File: ^02963::Q1
Data File: ^02963::Q2
Name: 96-4064-05 ;;;KL
Misc: ;;W;0;1;W;0;11/27/96;0

Quant Rev: 7 Quant Time: 961127 18:24
 Injected at: 961127 17:54
Dilution Factor: 1.00000
Instrument ID: VOA 1

ID File: ID_824::Q1

Title: ID FILE FOR APPENDIX NINE VOAs METHOD 8260A(8240)

Last Calibration: 961125 12:35

Last Qcal Time: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	g
1)	*BROMOCHLOROMETHANE(INT STD)	6.10	580	34600	50.00	UG/L	80
23)	1,2-DICHLOROETHANE-D4(SUR STD)	7.41	712	85398	53.27	UG/L	100
24)	*1,4-DIFLUOROBENZENE(INT STD)	8.57	829	166354	50.00	UG/L	100
46)	*CHLOROBENZENE-D5(INTERNAL STD)	14.42	1419	140659	50.00	UG/L	100
53)	TOLUENE-D8(SURROGATE STD)	11.47	1121	181121	50.46	UG/L	100
55)	CHLOROBENZENE	14.49	1426	2791	.965	UG/L	100
58)	BROMOFLUOROBENZENE(SURR STD)	17.05	1684	96503	49.26	UG/L	100
63)	1,2-DICHLOROBENZENE	20.37	2019	953	.408	UG/L	94
64)	1,4-DICHLOROBENZENE	19.60	1942	7957	3.10	UG/L	94

* Compound is ISTD

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF6-MPA(D)	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4064-06	Lab Project No.	: 96-4064
Date Sampled	: 11/17/96	Matrix	: Water
Date Received	: 11/18/96	Lab File No.	: HALL1125\014F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	6.6	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	1.2	0.4
cis-1,2-Dichloroethene	156-59-4	0.44 J X	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	20	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	0.88 J	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 93% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES: X = Not confirmed by MS (MDL 1ug/L).

Analyst

Approved

HLW4064.XLS; 12/2/96

QUANT REPORT

Page 1

Operator ID: KIM
Output File: ^U2964::Q1
Data File: ^U2964::U2
Name: 96-4064-06 ;;;KL
Misc: 5;W;0;1;W;0;11/27/96;0

Quant Rev: 7 Quant Time: 961127 18:52
 Injected at: 961127 18:28
Dilution Factor: 1.00000
Instrument ID: VOA 1

ID File: ID_824::QT
Title: ID FILE FOR APPENDIX NINE VOAs METHOD 8260A(8240)
Last Calibration: 961125 12:35 Last Cal Time: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	q
1)	*BROMOCHLOROMETHANE(INT STD)	6.14	584	35279	50.00	UG/L	82
4)	BROMOMETHANE	1.31	96	860	1.29	UG/L	100
5)	VINYL CHLORIDE	.98	63	11930M	9.06	UG/L	100
11)	METHYLENE CHLORIDE	2.90	252	913	.759	UG/L	37
17)	1,1 DICHLOROETHANE	4.15	383	6842	2.47	UG/L	100
23)	1,2 DICHLOROETHANE-D4(SUR STD)	7.48	719	87257	53.38	UG/L	100
24)	*1,4 DIFLUOROBENZENE(INT STD)	8.62	834	176110	50.00	UG/L	100
46)	*CHLOROBENZENE-D5(INTERNAL STD)	14.43	1420	145633	50.00	UG/L	100
53)	TOLUENE-D8(SURROGATE STD)	11.50	1124	185761	49.98	UG/L	100
55)	CHLOROBENZENE	14.47	1424	94670	31.61	UG/L	100
58)	BROMOFLUOROBENZENE(SURR STD)	17.06	1685	96035	47.34	UG/L	100
63)	1,2-DICHLOROBENZENE	20.37	2019	2266	.937	UG/L	77
64)	1,4-DICHLOROBENZENE	19.61	1942	49536	18.67	UG/L	96

* Compound is ISTD

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06-MW19	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4064-07	Lab Project No.	: 96-4064
Date Sampled	: 11/17/96	Matrix	: Water
Date Received	: 11/18/96	Lab File No.	: HALL1125\018F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 88% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

PAR8010W.XLS; 12/2/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06-MPR	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4064-08	Lab Project No.	: 96-4064
Date Sampled	: 11/17/96	Matrix	: Water
Date Received	: 11/18/96	Lab File No.	: HALL1126\006F0101
Date Prepared	: 11/26/96	Method Blank	: RB112696
Date Analyzed	: 11/26/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
Chlorotoluene	106-49-8	U	0.4
3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 89% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

PAR8010W.XLS; 12/2/96

Method 601/8010 Chlorinated VOC's Sample Report

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	4.2	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	13	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	0.8	0.4

NOTES:

Approved

QUANT REPORT

Page 1

Operator ID: KIM
Output File: >U2965::Q1
Data File: >U2965::U2
Name: 96-4064-09 ;;;KL
Misc: 5;W;0;1;W;0;11/27/96;0

Quant Rev: 7 Quant Time: 961127 19:19
 Injected at: 961127 18:55
Dilution Factor: 1.00000
Instrument ID: UCA 1

ID File: ID_824::Q1
Title: ID FILE FOR APPENDIX NINE UOAs METHOD 8269A(8240)
Last Calibration: 961125 12:35 Last Qcal Time: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	g
1)	*BROMOCHLOROMETHANE(INT STD)	6.14	584	33734	50.00	UG/L	81
4)	BROMOMETHANE	1.30	95	771M	1.21	UG/L	100
5)	VINYL CHLORIDE	.99	64	8873	7.04	UG/L	100
17)	1,1 DICHLOROETHANE	4.18	386	3692	1.36	UG/L	100
23)	1,2 DICHLOROETHANE-D4(SUR STD)	7.45	716	79881	51.11	UG/L	100
24)	*1,4 DIFLUOROBENZENE(INT STD)	8.60	832	165416	50.00	UG/L	100
46)	*CHLOROBENZENE-D5(INTERNAL STD)	14.41	1418	134110	50.00	UG/L	100
53)	TOLUENE-D8(SURROGATE STD)	11.50	1124	165947	48.49	UG/L	100
55)	CHLOROBENZENE	14.47	1424	63962	23.19	UG/L	100
58)	BROMOFLUOROBENZENE(SURR STD)	17.03	1682	86455	46.28	UG/L	100
63)	1,2-DICHLOROBENZENE	20.36	2018	2054	.922	UG/L	84
64)	1,4-DICHLOROBENZENE	19.59	1940	69048	28.26	UG/L	98

* Compound is ISID

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06-MPF(D)	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4064-10	Lab Project No.	: 96-4064
Date Sampled	: 11/17/96	Matrix	: Water
Date Received	: 11/18/96	Lab File No.	: HALL1125\021F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	1.7 J	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	6.1	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 81% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

QUANT REPORT

Page 1

Operator ID: KIM
Output File: ^V2966::Q1
Data File: >V2966::V2
Name: 96-4064-10 ;;;KL
Misc: 5;W;0;1;W;0;11/27/96;0

Quant Rev: 7 Quant Time: 961127 19:46
 Injected at: 961127 19:22
Dilution Factor: 1.00000
Instrument ID: VOA 1

ID File: ID_824::QT

Title: ID FILE FOR APPENDIX NINE VOAs METHOD 8260A(8240)

Last Calibration: 961125 12:35

Last Qcal Date: <none>

Compound	R.T.	Scan#	Area	Conc	Units	q
1) *BROMOCHLOROMETHANE(INT STD)	6.14	584	34237	50.00	UG/L	79
4) BROMOMETHANE	1.31	96	810	1.25	UG/L	100
5) VINYL CHLORIDE	.99	64	1849	1.45	UG/L	100
23) 1,2 DICHLOROETHANE-D4(SUR STD)	7.46	717	80532	50.77	UG/L	100
24) *1,4 DIFLUOROBENZENE(INT STD)	8.61	833	168480	50.00	UG/L	100
46) *CHLOROBENZENE-D5(INTERNAL STD)	14.41	1418	138860	50.00	UG/L	100
53) TOLUENE-D8(SURROGATE STD)	11.48	1122	172848	48.78	UG/L	100
55) CHLOROBENZENE	14.47	1424	35637	12.48	UG/L	100
58) BROMOFLUOROBENZENE(SURR STD)	17.04	1683	89320	46.18	UG/L	100
64) 1,4-DICHLOROBENZENE	19.58	1939	25976	10.27	UG/L	94

* Compound is ISTD

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : Trip Blank #7
Lab Sample No. : 96-4064-11
Date Sampled : 11/17/96
Date Received : 11/18/96
Date Prepared : 11/25/96
Date Analyzed : 11/25/96
Client Project No. : 729691.32010
Lab Project No. : 96-4064
Matrix : Water
Lab File No. : HALL1125\022F0101
Method Blank : RB112596
Dilution Factor : 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 83% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

PAR8010W.XLS; 12/2/96

Method 8010 Quality Control Samples

Date Performed: 11/25/96

Reference Standard: V832

Analyte	M	Method Blank	Sample 96-4064-06	Sample Spike	Spike Dup.	Control Spike	Spike Amt	RPD	Spike Recoveries			QC Recovery Range		
									Sample	Dup	# Control	% L - % H	Low	High
Vinyl Chloride	W		6.641	23.331	25.293	16.886	20.0	11.1	83%	93%		28 - 163	5.60	32.60
Chloroethane	*			18.504	19.768	19.268	20.0	6.6	93%	99%		46 - 137	9.20	27.40
1,1-Dichloroethene	*			18.334	18.644	19.713	20.0	1.7	92%	93%		28 - 167	5.60	33.40
Dichloromethane	*		0.105	16.867	18.358	18.624	20.0	8.5	84%	91%		25 - 162	5.00	32.40
trans-1,2-Dichloroethene	*			21.68	22.698	23.188	20.0	4.6	108%	113%		38 - 155	7.60	31.00
1,1-Dichloroethane	*		1.168	21.339	22.832	21.399	20.0	7.1	101%	108%		47 - 132	9.40	26.40
cis-1,2-Dichloroethene	*		0.438	21.454	22.411	21.414	20.0	4.5	105%	110%		-	-	-
1,1,1-Trichloroethane	*			20.253	20.633	21.329	20.0	1.9	101%	103%		41 - 138	8.20	27.60
Carbon Tetrachloride	*			20.29	21.154	21.504	20.0	4.2	101%	106%		43 - 143	8.60	28.60
Trichloroethene	W			23.016	21.14	22.011	20.0	8.5	115%	106%		35 - 146	7.00	29.20
1,1,2-Trichloroethane	W			20.375	20.758	22.008	20.0	1.9	102%	104%		39 - 136	7.80	27.20
Tetrachloroethene	*		0.115	22.404	21.707	21.617	20.0	3.2	111%	108%		26 - 162	5.20	32.40
1,1,1,2-Tetrachloroethane	*			19.447	18.92	19.287	20.0	2.7	97%	95%		-	-	-
Chlorobenzene	*		20.161	43.358	46.282	21.459	20.0	11.9	116%	131%		1 - 150	0.16	30.00
1,1,2,2-Tetrachloroethane	*			18.977	19.794	22.404	20.0	4.2	95%	99%		8 - 184	1.60	36.80
2-Chlorotoluene	*			17.9	19.701	19.169	20.0	9.6	90%	99%		-	-	-
4-Chlorotoluene	*			17.787	18.487	19.732	20.0	3.9	89%	92%		-	-	-
1,3-Dichlorobenzene	*			17.124	18.499	18.886	20.0	7.7	86%	92%		7 - 187	1.40	37.40
1,2-Dichlorobenzene	*		0.875	17.34	17.97	17.990	20.0	3.8	82%	85%		0 - 208	0.00	41.60

M = Applicable matrices. (* = Soil and Water. w = Water only.)

= Marks a spike recovery out of limits.

If recovery is outside method limit, marked with ***.

If recovery is outside a guideline, marked with ~.

If the sample spike recovery is outside the limit and the control spike is outside the limit also, the control is marked with *** or ~.

Notes on recovery limits:

All spiked analytes must be detected even if low limit is 0.

For analytes not listed in the method, recovery limits of 50-150% will be used as guidelines until limits can be established.

Corrective Actions:

Unacceptable sample spike recovery requires acceptable control spike recovery. If both recoveries are outside limits, corrective action must be taken. One recovery outside limits and the other acceptable, is a warning. Repeated failure requires corrective action.

Recoveries outside guidelines should be compared to historical data available to determine if corrective action is required.

PAR8010W.XLS; 12/2/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form
Method Blank Report

Method Blank Number	: GB112696	Client Project No.	: 729691.32010
Date Extracted/Prepared	: 11/26/96	Lab Work Order	: 96-4064
Date Analyzed	: 11/26/96	Dilution Factor	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS1126002

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers


E = Extrapolated value.


U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPN	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4064-01	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	Dilution Factor	: 1.00
Date Received	: 11/18/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/26/96	Matrix	: Water
Date Analyzed	: 11/26/96	Lab File No.	: GAS1126008

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.059	0.002

Temperature	: 70.6 F	Saturation Meth	: 0.014083379
Volume Injected	: 0.5 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	: 0.044490838
Head space created	: 4 ml	in Head Space	
Methane Area	: 327.502 ug		

Atomic weight(Methane) : 16 g

Qualifiers

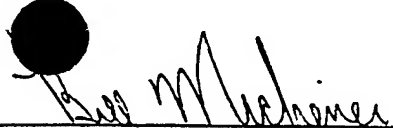
E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPC(S)	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4064-02	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	Dilution Factor	: 50.00
Date Received	: 11/18/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/26/96	Matrix	: Water
Date Analyzed	: 11/26/96	Lab File No.	: GAS1126009

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	1.9	0.1

Temperature	: 70.7 F	Saturation	Meth	0.4515
Amount Injected	: 0.01 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	1.42620713
Head space created	: 4 ml	in Head Space		
Methane Area	: 210.009 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPC(D)	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4064-03	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	Dilution Factor	: 10.00
Date Received	: 11/18/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/26/96	Matrix	: Water
Date Analyzed	: 11/26/96	Lab File No.	: GAS1126010

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.35	0.02

Temperature	: 71 F	Saturation Meth	: 0.083457379
Volume Injected	: 0.05 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	: 0.263451584
Head space created	: 4 ml	in Head Space	
Methane Area	: 194.076 ug		

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPJ	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4064-04	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	Dilution Factor	: 1.00
Date Received	: 11/18/96	Method	: RKSOP-175M
Date Extracted/Prepared	: 11/26/96	Matrix	: Water
Date Analyzed	: 11/26/96	Lab File No.	: GAS1126011


Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.017	0.002

Temperature	: 70.4 F	Saturation	Meth	0.004	1
Amount Injected	: 0.5 ml	Concentration			
Total Volume of Sample	: 43 ml	Concentration	Meth	0.0126	1185
Head space created	: 4 ml	in Head Space			
Methane Area	: 93.023 ug				

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPA(S)	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4064-05	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	Dilution Factor	: 10.00
Date Received	: 11/18/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/26/96	Matrix	: Water
Date Analyzed	: 11/26/96	Lab File No.	: GAS1126012

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.85	0.02

Temperature	: 70.5 F	Saturation	Meth	0.204831283
Amount Injected	: 0.05 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.647205133
Head space created	: 4 ml	in Head Space		
Methane Area	: 476.325 ug			

Atomic weight(Methane) : 16 g

Qualifiers


E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

*A = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF6-MPA(D)	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4064-06	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	Dilution Factor	: 10.00
Date Received	: 11/18/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/26/96	Matrix	: Water
Date Analyzed	: 11/26/96	Lab File No.	: GAS1126013

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.31	0.02

Temperature	: 70.8 F	Saturation Meth	: 0.074
Amount Injected	: 0.05 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	: 0.235
Head space created	: 4 ml	in Head Space	
Methane Area	: 173.395 ug		

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number : LF06-MW19 Client Project No. : 729691.32010
Lab Sample Number : 96-4064-07 Lab Work Order : 96-4064
Date Sampled : 11/17/96 Dilution Factor : 1.00
Date Received : 11/18/96 Method : RSKSOP-175M
Date Extracted/Prepared : 11/26/96 Matrix : Water
Date Analyzed : 11/26/96 Lab File No. : GAS1126014

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 70.3 F	Saturation	Meth	0
Volume Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0
Head space created	: 4 ml	in Head Space		
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers


E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF06-MPR	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4064-08	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	Dilution Factor	: 1.00
Date Received	: 11/18/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/26/96	Matrix	: Water
Date Analyzed	: 11/26/96	Lab File No.	: GAS1126016

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.012	0.002

Temperature	: 70.6 F	Saturation Meth	: 0.002
Amount Injected	: 0.5 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	: 0.0093658
Head space created	: 4 ml	in Head Space	
Methane Area	: 68.943 ug		

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Joe Michener
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF06-MPR	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4064-08Dup	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	Dilution Factor	: 1.00
Date Received	: 11/18/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/26/96	Matrix	: Water
Date Analyzed	: 11/26/96	Lab File No.	: GAS1126017

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.012	0.002

Temperature	: 70.7 F	Saturation	Meth	0.002767593
Volume Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.00874146
Head space created	: 4 ml	in Head Space		
Methane Area	: 64.359 ug			

Atomic weight(Methane) : 16 g

Qualifiers

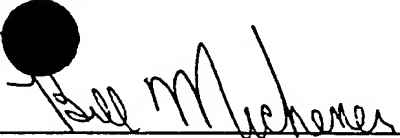
E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF06-MPD(D)	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4064-09	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	Dilution Factor	: 10.00
Date Received	: 11/18/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/26/96	Matrix	: Water
Date Analyzed	: 11/26/96	Lab File No.	: GAS1126018

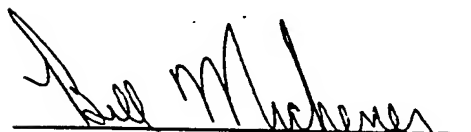
Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.24	0.02

Temperature	: 70.6 F	Saturation	Meth	0.0571
Amount Injected	: 0.05 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.1805
Head space created	: 4 ml	in Head Space		
Methane Area	: 132.894 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF06-MPF(D)	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4064-10	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	Dilution Factor	: 10.00
Date Received	: 11/18/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/26/96	Matrix	: Water
Date Analyzed	: 11/26/96	Lab File No.	: GAS1126019

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.44	0.02

Temperature	: 70.9 F	Saturation Meth	: 0.104705306
Volume Injected	: 0.05 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	: 0.330587667
Head space created	: 4 ml	in Head Space	
Methane Area	: 243.487 ug		

Atomic weight(Methane) : 16 g

Qualifiers


E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

NA = Not Available/Not Applicable.


Analyst


Approved

RSKSOP-175M Gas Method
Methane Gas Matrix Spike / Matrix Spike Duplicate Report

Client Sample No.	: LF6-MPJ	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4064-04	Lab Work Order	: 96-4064
Date Sampled	: 11/17/96	EPA Method No.	: RSKSOP-175M
Date Received	: 11/18/96	Matrix	: Water
Date Prepared	: 11/26/96	Method Blank	: GB112696
Date Analyzed	: 11/26/96	Lab File No's.	: GAS1126020,021
E.A. MS/MSD Spike Source No.	: 1886		

Compound	Spike Added (ug)	Sample Concentration (ug)	MS Concentration (ug)	MS %REC	QC Limits %REC
Methane Gas	500	93	429	67	47-88

Compound	Spike Added (ug)	MSD Concentration (ug)	MSD %REC	RPD	QC Limits RPD	QC Limits %REC
Methane Gas	500	427	67	0.5	0-16.4	47-88

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes

* = Values outside of QC limits.

NA = Not analyzed/not available

Note: The Spike was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Analyst

Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

**RSKSOP-175M Gas Method
Methane LCS Report Form**

LCS No. : LCS112696 EPA Method No. : RSKSOP-175M
Date Prepared : 11/26/96 Matrix : Water
Date Analyzed : 11/26/96 Method Blank : GB112696
E.A. LCS Source No. : 1886 Lab File No. : GAS1126006


Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	436	87	64-90

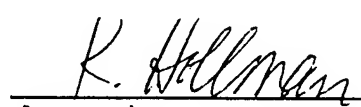
Spike Recovery: 0 out of (1) outside limits.

Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes

* = Values outside of QC limits.
NA = Not analyzed/not available.


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/17/96
Date Received : 11/18/96
Date Prepared : 11/18/96
Date Analyzed : 11/18/96

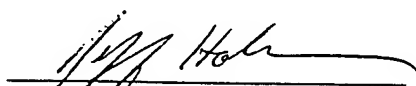
Client Project ID. : 729691.32010
Lab Project Number : 96-4064
Method : EPA 300.0
Detection Limit : 0.25 mg/L

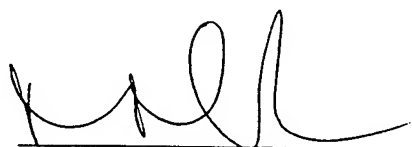
<u>Evergreen Sample #</u>	<u>Client Sample ID.</u>	<u>Matrix</u>	<u>Chloride (mg/L)</u>	<u>Dilution Factor</u>
96-4064-01	LF6-MPN	Water	23.1	10
96-4064-02	LF6-MPC(S)	Water	13.2	1
96-4064-03	LF6-MPC(D)	Water	36.6	10
96-4064-04	LF6-MPJ	Water	23.4	1
96-4064-05	LF6-MPA(S)	Water	4.2	1
96-4064-06	LF6-MPA(D)	Water	18.4	1
96-4064-07	LF06-MW19	Water	2.3	1
96-4064-08	LF06-MPR	Water	271	10
96-4064-09	LF06-MPD(D)	Water	7.2	1
96-4064-10	LF06-MPF(D)	Water	22.4	1
Method Blank	(11/18/96)	Water	<0.25	1

Quality Assurance*

<u>Reference</u>	<u>True Value (mg/L)</u>	<u>Result (mg/L)</u>	<u>% Recovery</u>
Alltech Anion Mixtue A Lot # 728550	20.0	19.6	98

* = Laboratory control sample results reported for quality assurance due to spike values exceeding calibration range. No duplicate of diluted sample analyzed.


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/17/96
Date Received : 11/18/96
Date Prepared : 11/18/96
Date Analyzed : 11/18/96

Client Project ID. : 729691.32010
Lab Project Number : 96-4064
Method : EPA 300.0
Detection Limit : 0.076 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N (mg/L)	Dilution Factor
96-4064-01	LF6-MPN	Water	<0.076	1
96-4064-01 Duplicate	LF6-MPN Duplicate	Water	<0.076	1
96-4064-02	LF6-MPC(S)	Water	<0.076	1
96-4064-03	LF6-MPC(D)	Water	<0.076	1
96-4064-04	LF6-MPJ	Water	<0.076	1
96-4064-05	LF6-MPA(S)	Water	<0.076	1
96-4064-06	LF6-MPA(D)	Water	<0.076	1
96-4064-07	LF06-MW19	Water	<0.076	1
96-4064-08	LF06-MPR	Water	<0.76**	10
96-4064-09	LF06-MPD(D)	Water	<0.076	1
96-4064-10	LF06-MPF(D)	Water	<0.076	1
Method Blank	(11/18/96)	Water	<0.076	1

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-4064-01	LF6-MPN Matrix Spike	10.0	<0.25	9.6	96
96-4064-01	LF6-MPN Matrix Spike Dup	10.0	<0.25	9.2	92


MS/MSD RPD

4.0

* = Quality assurance results reported as Nitrite (NO₂).

** = Raised detection limit due to matrix interference.


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/17/96
Date Received : 11/18/96
Date Prepared : 11/18/96
Date Analyzed : 11/18/96

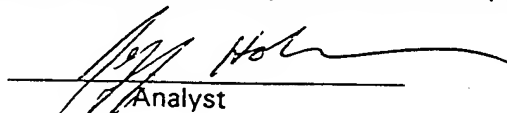
Client Project ID. : 729691.32010
Lab Project Number : 96-4064
Method : EPA 300.0
Detection Limit : 0.056 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrate-N (mg/L)	Dilution Factor
96-4064-01	LF6-MPN	Water	<0.056	1
96-4064-01 Duplicate	LF6-MPN Duplicate	Water	<0.056	1
96-4064-02	LF6-MPC(S)	Water	<0.056	1
96-4064-03	LF6-MPC(D)	Water	0.39	1
96-4064-04	LF6-MPJ	Water	<0.056	1
96-4064-05	LF6-MPA(S)	Water	<0.056	1
96-4064-06	LF6-MPA(D)	Water	<0.056	1
96-4064-07	LF06-MW19	Water	0.81	1
96-4064-08	LF06-MPR	Water	0.30	1
96-4064-09	LF06-MPD(D)	Water	<0.056	1
96-4064-10	LF06-MPF(D)	Water	<0.056	1
Method Blank	(11/18/96)	Water	<0.056	1

Quality Assurance *

	Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-4064-01 LF6-MPN Matrix Spike	10.0	<0.25	9.3	93
96-4064-01 LF6-MPN Matrix Spike Dup	10.0	<0.25	9.1	91
MS/MSD RPD				2.0

* = Quality assurance results reported as Nitrate (NO₃).


Analyst


Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 11/17/96
Date Received : 11/18/96
Date Prepared : 11/18/96
Date Analyzed : 11/18/96


Client Project ID. : 729691.32010
Lab Project Number : 96-4064
Method : EPA 300.0
Detection Limit : 0.25 mg/L

<u>Evergreen Sample #</u>	<u>Client Sample ID.</u>	<u>Matrix</u>	<u>Sulfate (mg/L)</u>	<u>Dilution Factor</u>
96-4064-01	LF6-MPN	Water	2.3	1
96-4064-01 Duplicate	LF6-MPN Duplicate	Water	2.2	1
96-4064-02	LF6-MPC(S)	Water	4.0	1
96-4064-03	LF6-MPC(D)	Water	<0.25	1
96-4064-04	LF6-MPJ	Water	0.36	1
96-4064-05	LF6-MPA(S)	Water	119	10
96-4064-06	LF6-MPA(D)	Water	1.3	1
96-4064-07	LF06-MW19	Water	11.0	1
96-4064-08	LF06-MPR	Water	0.88	1
96-4064-09	LF06-MPD(D)	Water	4.8	1
96-4064-10	LF06-MPF(D)	Water	1.0	1
Method Blank	(11/18/96)	Water	<0.25	1

Quality Assurance

	<u>Spike Amount (mg/L)</u>	<u>Sample Result (mg/L)</u>	<u>Spike Result (mg/L)</u>	<u>% Recovery</u>
96-4064-01 LF6-MPN Matrix Spike	10.0	2.3	11.5	93
96-4064-01 LF6-MPN Matrix Spike Dup	10.0	2.3	11.2	90
MS/MSD RPD				3.2


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF06-MPG Client Project Number : 729691.32010
Lab Sample Number : 96-4081-02 Lab Work Order : 96-4081
Date Sampled : 11/18/96 Matrix : WATER
Date Received : 11/19/96 Lab File Number(s) : TVB21120008
Date Prepared : 11/20/96 Method Blank : MB2112096
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/20/96	U	0.1	mg/L
Benzene	71-43-2	11/20/96	U	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	U	0.5	ug/L
Surrogate Recovery:		96%		70%-126%	(Limits)
Surrogate Recovery:		99%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : W3 Client Project Number : 729691.32010
Lab Sample Number : 96-4081-04 Lab Work Order : 96-4081
Date Sampled : 11/18/96 Matrix : WATER
Date Received : 11/19/96 Lab File Number(s) : TVB21120010
Date Prepared : 11/20/96 Method Blank : MB2112096
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/20/96	0.3	0.1	mg/L
Benzene	71-43-2	11/20/96	15	0.4	ug/L
Toluene	108-88-3	11/20/96	1.2	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	2.7	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	3.5	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	0.4	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	8.4	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	27	0.5	ug/L
FID Surrogate Recovery:		123%		70%-126%	(Lin
PID Surrogate Recovery:		121%		76%-127%	(Lin

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF06-MPF(S) Client Project Number : 729691.32010
Lab Sample Number : 96-4081-05 Lab Work Order : 96-4081
Date Sampled : 11/18/96 Matrix : WATER
Date Received : 11/19/96 Lab File Number(s) : TVB21120011*
Date Prepared : 11/20,25/96 Method Blanks : MB2112096*
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0; 20

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/20/96	0.6	0.1	mg/L
Benzene	71-43-2	11/20/96	12	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/25/96	300	8.0	ug/L
Ethyl Benzene	100-41-4	11/20/96	22	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	14	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	3.4	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	9.9	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	5.1	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	5.7	0.5	ug/L
PID Surrogate Recovery: 112% 70%-126% (Limits)					
Surrogate Recovery: 114%; 91% 76%-127% (Limits)					

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: *TVB21125010 and MB2112596

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF06-MPV Client Project Number : 729691.32010
Lab Sample Number : 96-4081-06 Lab Work Order : 96-4081
Date Sampled : 11/18/96 Matrix : WATER
Date Received : 11/19/96 Lab File Number(s) : TVB21120029,56
Date Prepared : 11/21,22/96 Method Blanks : MB2112196
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0; 20

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Unit
TVH-Gasoline	----	11/21/96	0.6	0.1	mg/L
Benzene	71-43-2	11/21/96	12	0.4	ug/L
Toluene	108-88-3	11/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/22/96	280	8.0	ug/L
Ethyl Benzene	100-41-4	11/21/96	21	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/21/96	14	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/21/96	3.5	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/21/96	10	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/21/96	4.9	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/21/96	5.0	0.5	ug/L
FID Surrogate Recovery:		106%		70%-126%	
PID Surrogate Recovery:		105%;96%		76%-127%	

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blechta

Analyst

A. McCall

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number : LF06-MPB Client Project Number : 729691.32010
Lab Sample Number : 96-4081-08 Lab Work Order : 96-4081
Date Sampled : 11/18/96 Matrix : WATER
Date Received : 11/19/96 Lab File Number(s) : TVB21120013
Date Prepared : 11/20/96 Method Blank : MB2112096
FID Dilution Factor : 1.0
PID Dilution Factor : 1.0

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	11/20/96	U	0.1	mg/L
Benzene	71-43-2	11/20/96	U	0.4	ug/L
Toluene	108-88-3	11/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	11/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	11/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	11/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	11/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	11/20/96	0.9	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	11/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	11/20/96	0.6	0.5	ug/L
Surrogate Recovery:		111%		70%-126%	(Limits)
Surrogate Recovery:		104%		76%-127%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.


Analyst


Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: W3	Client Project No.	: 72691.32010
Lab Sample No.	: 96-4081-04	Lab Work Order	: 96-4081
Date Sampled	: 11/18/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 11/19/96	Matrix	: WATER
Date Prepared	: 11/20/96	Lab File Number(s)	: TVB21120023,24
Date Analyzed	: 11/21/96	Method Blank	: MB2112096
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#) Limits
Gasoline	2.00	0.34	2.49	107.7%	60 - 128
Surrogate **	---	---	---	136% *	70 - 126

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#) Limits
Gasoline	2.00	2.49	107.5%	0.1	44.1
Surrogate **	---	---	133% *	NA	NA

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:

NA = Not analyzed/not applicable.

* = Values outside of QC limits.

** = 1,2,4-Trichlorobenzene

= Limits established 10/1/96, MAB

Comments: * = High Surrogate Recovery due to hydrocarbon interference.

M. Blech
Analyst

K. Hollman
Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: LF06-MPG	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4081-02	Lab Work Order	: 96-4081
Date Sampled	: 11/18/96	EPA Method No.	: 602/8020
Date Received	: 11/19/96	Matrix	: WATER
Date Prepared	: 11/20/96	Lab File Number(s)	: TVB21120021,22
Date Analyzed	: 11/20/96	Method Blank	: MB2112096
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L)		Comments
			MS	MSD	
Benzene	20.0	0.0	21.9	22.1	
Toluene	20.0	0.0	21.2	21.6	
Chlorobenzene	20.0	0.0	21.0	21.3	
Ethylbenzene	20.0	0.0	21.1	21.5	
m,p-Xylene	20.0	0.0	21.1	21.5	
o-Xylene	20.0	0.0	21.0	21.3	
1,3,5-TMB	20.0	0.0	20.7	21.0	
1,2,4-TMB	20.0	0.0	20.4	20.8	
1,2,3-TMB	20.0	0.0	21.0	21.3	
1,2,3,4-TeMB	20.0	0.0	21.2	21.3	
Surrogate	100.0	99%	106%	103%	% RECOVERY

Compound	MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits		
				RPD	%REC	
Benzene	109.5	110.5	0.9	17	61	129
Toluene	106.0	108.0	1.9	18	61	127
Chlorobenzene	105.0	106.5	1.4	16	68	122
Ethylbenzene	105.5	107.5	1.9	18	63	126
m,p-Xylene	105.5	107.5	1.9	18	60	130
o-Xylene	105.0	106.5	1.4	18	62	128
1,3,5-TMB	103.5	105.0	1.4	18	69	117
1,2,4-TMB	102.0	104.0	1.9	23	69	119
1,2,3-TMB	105.0	106.5	1.4	16	71	118
1,2,3,4-TeMB	106.0	106.5	0.5	27	67	125
Surrogate	106.0	103.0	NA	NA	76	127

= Limits established 10/15/96, KSH

* = Values outside of QC limits.

RPD: 0 out of (10) outside limits.

Spike Recovery: 0 out of (20) outside limits.

Comments: _____

M. Blech
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No. : LF06-MPG Client Project No. : 729691.32010
Lab Sample No. : 96-4081-02 Lab Project No. : 96-4081
Date Sampled : 11/18/96 Matrix : Water
Date Received : 11/19/96 Lab File No. : HALL1125\024F0101
Date Prepared : 11/25/96 Method Blank : RB112596
Date Analyzed : 11/25/96 Dilution Factor : 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.42
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 71% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4081.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: W3	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4081-04	Lab Project No.	: 96-4081
Date Sampled	: 11/18/96	Matrix	: Water
Date Received	: 11/19/96	Lab File No.	: HALL1125\027F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
1-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 76% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4081.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: W3 DUP	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4081-04 DUP	Lab Project No.	: 96-4081
Date Sampled	: 11/18/96	Matrix	: Water
Date Received	: 11/19/96	Lab File No.	: HALL1126\025F0101
Date Prepared	: 11/26/96	Method Blank	: RB112696
Date Analyzed	: 11/27/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 85% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4081.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06-MPF(S)	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4081-05	Lab Project No.	: 96-4081
Date Sampled	: 11/18/96	Matrix	: Water
Date Received	: 11/19/96	Lab File No.	: HALL1125\026F0101
Date Prepared	: 11/25/96	Method Blank	: RB112596
Date Analyzed	: 11/25/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	E	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	4.2	0.4
1,2-Dichlorobenzene	95-50-1	4.9	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 105% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4081.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06-MPF(S)	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4081-05	Lab Project No.	: 96-4081
Date Sampled	: 11/18/96	Matrix	: Water
Date Received	: 11/19/96	Lab File No.	: HALL1126\024F0101
Date Prepared	: 11/26/96	Method Blank	: RB112696
Date Analyzed	: 11/27/96	Dilution Factor	: 5.0

<u>Compound</u>	<u>CAS #</u>	<u>Concentration (ug/L)</u>	<u>RL (ug/L)</u>
Chlorobenzene	108-90-7	200	2.

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 95% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4081.XLS; 11/27/96

QUANT REPORT

Page 1

Operator ID: KIM
 Output File: >U2967::U1
 Data File: >U2967::U2
 Name: 96-4081-05 ;;;KL
 Misc: 5;W;0;1;W;0;11/22/96;0

Quant Rev: 7 Quant Time: 961127 20:18
 Injected at: 961127 19:49
 Dilution Factor: 1.00000
 Instrument ID: UGA 1

ID File: ID_824::01
 Title: ID FILE FOR APPENDIX NINE UGAs METHOD 8260A(S240)
 Last Calibration: 961125 12:35 Last Qcal Time: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	g
1)	BROMOCHLOROMETHANE (INT STD)	6.13	583	32771	50.00	UG/L	78
4)	BROMOMETHANE	1.31	96	939	1.52	UG/L	100
23)	1,2-DICHLOROETHANE-D4 (SUR STD)	7.45	716	82452	54.30	UG/L	100
24)	1,4-DIFLUOROBENZENE (INT STD)	8.61	833	152415	50.00	UG/L	100
46)	CHLOROBENZENE-D5 (INTERNAL STD)	14.43	1420	124617	50.00	UG/L	100
55)	TOLUENE-D8 (SURROGATE STD)	11.49	1123	165033	51.90	UG/L	100
55)	CHLOROBENZENE	14.47	1424	915283	357.12	UG/L	100
58)	BROMOFLUOROBENZENE (SURR STD)	17.05	1604	90708	52.26	UG/L	100
62)	1,3-DICHLOROBENZENE	19.36	1917	13342	6.20	UG/L	92
63)	1,2-DICHLOROBENZENE	20.35	2016	13593	6.57	UG/L	77
64)	1,4-DICHLOROBENZENE	19.59	1940	61171	26.94	UG/L	99

* Compound is ISID

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06-MPV	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-06	Lab Project No.	: 96-4081
Date Sampled	: 11/18/96	Matrix	: Water
Date Received	: 11/19/96	Lab File No.	: HALL1126\009F0101
Date Prepared	: 11/26/96	Method Blank	: RB112696
Date Analyzed	: 11/26/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	E	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	4.5	0.4
1,2-Dichlorobenzene	95-50-1	5.2	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 109% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.

B = Compound in blank and sample. Compare blank and sample data.

E = Extrapolated value. Concentration exceeds the upper limit of the calibration.

RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4081.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06-MPV	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4058-06	Lab Project No.	: 96-4081
Date Sampled	: 11/18/96	Matrix	: Water
Date Received	: 11/19/96	Lab File No.	: HALL1126\016F0101
Date Prepared	: 11/26/96	Method Blank	: RB112696
Date Analyzed	: 11/26/96	Dilution Factor	: 5.0

<u>Compound</u>	<u>CAS #</u>	<u>Concentration (ug/L)</u>	<u>RL (ug/L)</u>
Chlorobenzene	108-90-7	190	2.1

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 91% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4081.XLS; 11/27/96

QUANT REPORT

Page 1

Operator ID: KIM
 Output File: ^U2968::Q1
 Data File: >U2968::U2
 Name: 96-4081-06 ;;;KL
 Misc: 5;W;0;1;W;0;11/27/96;0

Quant Rev: 7 Quant Time: 961127 20:52
 Injected at: 961127 20:23
 Dilution Factor: 1.00000
 Instrument ID: UUA 1

ID File: ID_824::Q1

Title: ID FILE FOR APPENDIX NINE VOAs METHOD 826UA(8240)

Last Calibration: 961125 12:35

Last Qcal Time: <none>

	Compound	R.T.	Scan#	Area	Conc	Units	Q
1)	*BROMOCHLOROMETHANE(INT STD)	6.16	586	33660	50.00	UG/L	8
4)	BROMOMETHANE	1.31	96	875	1.38	UG/L	10
23)	1,2-DICHLOROETHANE-D4(SUR STD)	7.48	719	82820	53.11	UG/L	10
24)	*1,4-DIFLUOROBENZENE(INT STD)	8.63	835	164914	50.00	UG/L	10
46)	*CHLOROBENZENE-D5(INTERNAL STD)	14.45	1422	136608	50.00	UG/L	10
53)	TOLUENE-D8(SURROGATE STD)	11.52	1126	176060	50.50	UG/L	10
55)	CHLOROBENZENE	14.50	1427	990999	352.73	UG/L	10
58)	PERMETHYLBENZENE(SURR STD)	17.06	1685	94543	49.69	UG/L	10
62)	1,3-DICHLOROBENZENE	19.38	1919	14389	6.10	UG/L	9
63)	1,2-DICHLOROBENZENE	20.39	2020	14683	6.47	UG/L	9
64)	1,4-DICHLOROBENZENE	19.61	1942	66086	26.55	UG/L	9

* Compound is ISID

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06-MPB	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4081-08	Lab Project No.	: 96-4081
Date Sampled	: 11/18/96	Matrix	: Water
Date Received	: 11/19/96	Lab File No.	: HALL1126\011F0101
Date Prepared	: 11/26/96	Method Blank	: RB112696
Date Analyzed	: 11/26/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
Chlorotoluene	106-49-8	U	0.4
1,2-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 81% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4081.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: LF06 Field Blank	Client Project No.	: 729691.32010
Lab Sample No.	: 96-4081-10	Lab Project No.	: 96-4081
Date Sampled	: 11/18/96	Matrix	: Water
Date Received	: 11/19/96	Lab File No.	: HALL1126\023F0101
Date Prepared	: 11/26/96	Method Blank	: RB112696
Date Analyzed	: 11/27/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.4
2-Chlorotoluene	95-49-8	U	
4-Chlorotoluene	106-49-8	U	
1,3-Dichlorobenzene	541-73-1	U	
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 85% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW4081.XLS; 11/27/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF06-MPG	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4081-02	Lab Work Order	: 96-4081
Date Sampled	: 11/18/96	Dilution Factor	: 1.00
Date Received	: 11/19/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122023


Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 68.8 F	Saturation	Meth	0
Amount Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0
Head space created	: 4 ml	in Head Space		
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF06-MPF(S)	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4081-05	Lab Work Order	: 96-4081
Date Sampled	: 11/18/96	Dilution Factor	: 50.00
Date Received	: 11/19/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122025

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	6.5	0.1

Temperature	: 69.1 F	Saturation	Meth	1.548
Amount Injected	: 0.01 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	4.90690558
Head space created	: 4 ml	in Head Space		
Methane Area	: 720.361 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Bill Michener
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF06-MPF(S)	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4081-05Dup	Lab Work Order	: 96-4081
Date Sampled	: 11/18/96	Dilution Factor	: 50.00
Date Received	: 11/19/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122026

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	6.6	0.1


Temperature	: 69 F	Saturation Meth	: 1.590635913
Amount Injected	: 0.01 ml	Concentration	
Total Volume of Sample	: 43 ml	Concentration Meth	: 5.040197578
Head space created	: 4 ml	in Head Space	
Methane Area	: 739.789 ug		

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
N/A = Not Available/Not Applicable.


Analyst


Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: LF06-MPB	Client Project No.	: 729691.32010
Lab Sample Number	: 96-4081-08	Lab Work Order	: 96-4081
Date Sampled	: 11/18/96	Dilution Factor	: 50.00
Date Received	: 11/19/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 11/22/96	Matrix	: Water
Date Analyzed	: 11/22/96	Lab File No.	: GAS1122028

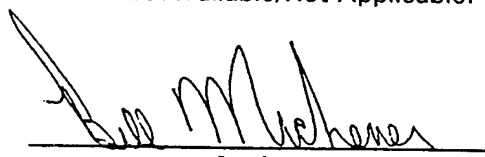
Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	4.7	0.1

Temperature	: 70.8 F	Saturation	Meth	1.1248 E
Amount Injected	: 0.01 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	3.5520 E
Head space created	: 4 ml	in Head Space		
Methane Area	: 523.143 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.


Analyst


Approved

APPENDIX C
ANALYTICAL MODEL OUTPUT

**Transient Solution to the Advective-Dispersive Equation for One-Dimensional Flow,
Type Three Boundary Condition (0.048 mg/L source no decay, with a 0.0053 day⁻¹
anaerobic decay coefficient, Constant Time, Variable Location)**

Hydrogeologic Data

Hydraulic conductivity	$K := 30.18 \cdot \frac{\text{m}}{\text{day}}$
Hydraulic gradient	$I := 0.0055 \cdot \frac{\text{ft}}{\text{ft}}$
Effective porosity	$n_e := 0.25$
Total porosity	$n := 0.3$
Longitudinal dispersivity	$\alpha_x := 30 \cdot \text{m}$
Concentration of Injected Contaminant	$C_s := 0.048 \cdot \frac{\text{mg}}{\text{liter}}$
Initial Dissolved Contaminant Concentration	$C_o := 0 \cdot \frac{\text{mg}}{\text{liter}}$

Retardation Coefficient Calculation

Solute Decay Rate	$\lambda := 0.0053 \cdot \frac{1}{\text{day}}$	
Source Decay Rate	$\gamma := 0.00000 \cdot \frac{1}{\text{day}}$	
Soil sorption coefficient (EPA, 1990)	$K_{oc} := 79 \cdot \frac{\text{mL}}{\text{gm}}$	
Bulk density (Freeze and Cherry, 1979)	$\rho_b := 1.65 \cdot \frac{\text{gm}}{\text{cm}^3}$	
Organic carbon content	$f_{oc} := 0.06 \cdot \%$	
Retardation coefficient	$R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$	$R = 1.261$

Groundwater Hydraulics Calculations

Groundwater velocity (pore-water)	$v_x := \frac{K \cdot I}{n_e}$	$v_x = 0.664 \cdot \frac{\text{m}}{\text{day}}$
Contaminant velocity	$v_c := \frac{v_x}{R}$	$v_c = 0.527 \cdot \frac{\text{m}}{\text{day}}$
Longitudinal dispersion coefficient	$D_x := \alpha_x \cdot v_x$	$D_x = 214.404 \cdot \frac{\text{ft}^2}{\text{day}}$

Initial Plume Distribution Calculation

$$j := 0..3000$$

$$t := 730 \text{ day}$$

$$\Delta x := 1 \text{ m}$$

$$x_j := \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

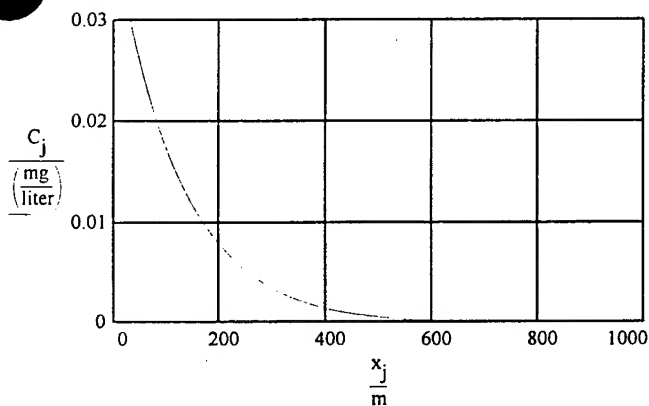
$$C_j := C_o \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots \right.$$

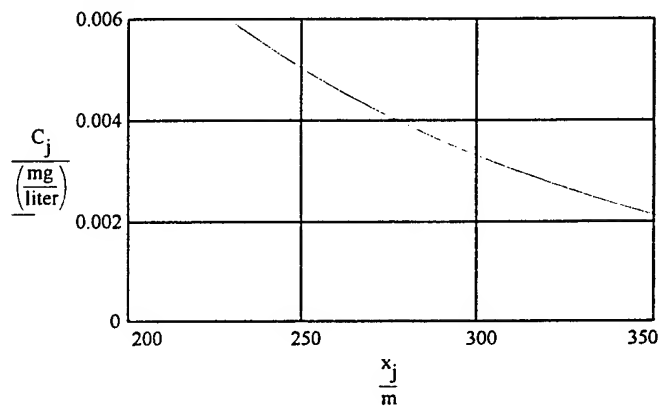
$$+ \left[\frac{v_x}{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right]$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



**Transient Solution to the Advective-Dispersive Equation for One-Dimensional Flow,
Type Three Boundary Condition (0.048 mg/L source with no decay, a 0.0053 day⁻¹
anaerobic decay coefficient, Constant Location, Variable Time)**

Hydrogeologic Data

Hydraulic conductivity	$K := 30.18 \cdot \frac{\text{m}}{\text{day}}$
Hydraulic gradient	$I := 0.0055 \cdot \frac{\text{ft}}{\text{ft}}$
Effective porosity	$n_e := 0.25$
Total porosity	$n := 0.3$
Longitudinal dispersivity (EPRI, 1985)	$\alpha_x := 30 \cdot \text{m}$
Concentration of Injected Contaminant	$C_s := 0.048 \cdot \frac{\text{mg}}{\text{liter}}$
Initial Dissolved Contaminant Concentration	$C_o := 0 \cdot \frac{\text{mg}}{\text{liter}}$

Retardation Coefficient Calculation

Solute Decay Rate	$\lambda := 0.0053 \cdot \frac{1}{\text{day}}$	
Source Decay Rate	$\gamma := 0.00000 \cdot \frac{1}{\text{day}}$	
Soil sorption coefficient (EPA, 1990)	$K_{oc} := 79 \cdot \frac{\text{mL}}{\text{gm}}$	
Bulk density (Freeze and Cherry, 1979)	$\rho_b := 1.65 \cdot \frac{\text{gm}}{\text{cm}^3}$	
Organic carbon content	$f_{oc} := 0.06 \cdot \%$	
Retardation coefficient	$R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$	$R = 1.261$

Groundwater Hydraulics Calculations

Groundwater velocity (pore-water)	$v_x := \frac{K \cdot I}{n_e}$	$v_x = 0.664 \cdot \frac{\text{m}}{\text{day}}$
Contaminant velocity	$v_c := \frac{v_x}{R}$	$v_c = 0.527 \cdot \frac{\text{m}}{\text{day}}$
Longitudinal dispersion coefficient	$D_x := \alpha_x \cdot v_x$	$D_x = 214.404 \cdot \frac{\text{ft}^2}{\text{day}}$

250 Meters Downgradient from Highest Total BTEX Concentration

Initial Plume Distribution Calculation

$$\text{year} = 365 \cdot \text{day} \quad i = 1 \dots 100$$

$$x = 250 \cdot \text{m}$$

$$\Delta t = 1 \cdot \text{year}$$

$$t_i = \Delta t \cdot i$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

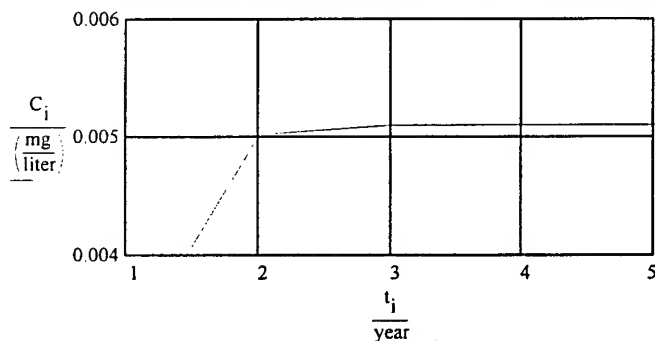
$$C_i = C_o \cdot \exp(-\lambda \cdot t_i) \cdot \left[1 - \frac{1}{2} \left(1 - \operatorname{erf} \left(\frac{R \cdot x - v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) - \left(\frac{v_x^2 \cdot t_i}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x - v_x \cdot t_i)^2}{4 \cdot D_x \cdot R \cdot t_i} \right] + \frac{1}{2} \left(1 + \frac{v_x \cdot x}{D_x} + \frac{v_x^2 \cdot t_i}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x + v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t_i) \cdot \left[\frac{v_x}{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x - t_i \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right] \dots \right.$$

$$+ \left[\frac{v_x}{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x + t_i \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x}{D_x} - (\lambda - \gamma) \cdot t_i \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x + v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) \right]$$

Concentration of BTEX (mg/L) versus Time (years)



**Transient Solution to the Advective-Dispersive Equation for One-Dimensional Flow,
Type Three Boundary Condition (0.015 mg/L benzene source, no source decay, with a
0.0053 day⁻¹ anaerobic decay coefficient, Constant Time, Variable Location)**

Hydrogeologic Data

Hydraulic conductivity	$K := 30.18 \frac{\text{m}}{\text{day}}$
Hydraulic gradient	$I := 0.0055 \frac{\text{ft}}{\text{ft}}$
Effective porosity	$n_e := 0.25$
Total porosity	$n := 0.3$
Longitudinal dispersivity	$\alpha_x := 30 \text{ m}$
Concentration of Injected Contaminant	$C_s := 0.015 \frac{\text{mg}}{\text{liter}}$
Initial Dissolved Contaminant Concentration	$C_o := 0 \frac{\text{mg}}{\text{liter}}$

Retardation Coefficient Calculation

Solute Decay Rate	$\lambda := 0.0053 \frac{1}{\text{day}}$	
Source Decay Rate	$\gamma := 0.00000 \frac{1}{\text{day}}$	
Soil sorption coefficient (EPA, 1990)	$K_{oc} := 79 \frac{\text{mL}}{\text{gm}}$	
Bulk density (Freeze and Cherry, 1979)	$\rho_b := 1.65 \frac{\text{gm}}{\text{cm}^3}$	
Organic carbon content	$f_{oc} := 0.06 \%$	
Retardation coefficient	$R := 1 + \frac{\rho_b K_{oc} f_{oc}}{n}$	$R = 1.261$

Groundwater Hydraulics Calculations

Groundwater velocity (pore-water)	$v_x := \frac{K \cdot I}{n_e}$	$v_x = 0.664 \frac{\text{m}}{\text{day}}$
Contaminant velocity	$v_c := \frac{v_x}{R}$	$v_c = 0.527 \frac{\text{m}}{\text{day}}$
Longitudinal dispersion coefficient	$D_x := \alpha_x \cdot v_x$	$D_x = 214.404 \frac{\text{ft}^2}{\text{day}}$

Initial Plume Distribution Calculation

$$j = 0..3000$$

$$t := 730 \cdot \text{day}$$

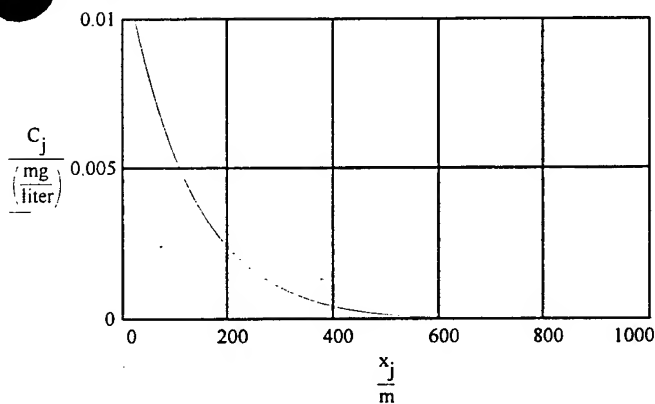
$$\Delta x := 1 \cdot \text{m}$$

$$x_j := \Delta x \cdot j$$

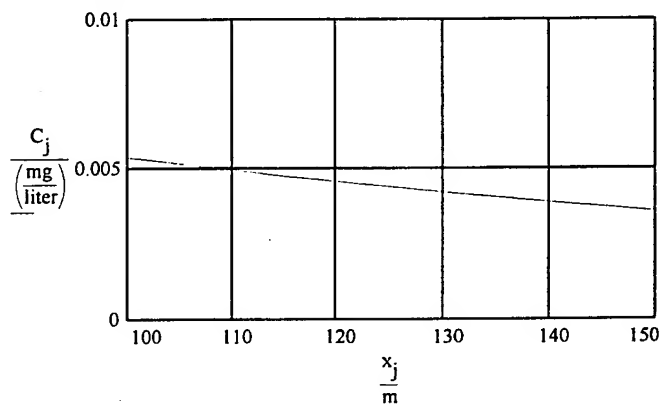
For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

$$C_j = C_o \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \cdot \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \\ + C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \right. \\ + \left[\frac{v_x}{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \right. \\ \left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right]$$

Dissolved Benzene (mg/L) Concentration versus Distance (m)



Dissolved Benzene (mg/L) Concentration versus Distance (m)



**Transient Solution to the Advective-Dispersive Equation for One-Dimensional Flow,
Type Three Boundary Condition (0.015 mg/L benzene source with no decay, a 0.0053
day⁻¹ anaerobic decay coefficient, Constant Location, Variable Time)**

Hydrogeologic Data

Hydraulic conductivity	$K = 30.18 \frac{\text{m}}{\text{day}}$
Hydraulic gradient	$I = 0.0055 \frac{\text{ft}}{\text{ft}}$
Effective porosity	$n_e = 0.25$
Total porosity	$n = 0.3$
Longitudinal dispersivity (EPRI, 1985)	$\alpha_x = 30 \text{ m}$
Concentration of Injected Contaminant	$C_s = 0.015 \frac{\text{mg}}{\text{liter}}$
Initial Dissolved Contaminant Concentration	$C_o = 0 \frac{\text{mg}}{\text{liter}}$

Retardation Coefficient Calculation

Solute Decay Rate	$\lambda = 0.0053 \frac{1}{\text{day}}$	
Source Decay Rate	$\gamma = 0.00000 \frac{1}{\text{day}}$	
Soil sorption coefficient (EPA, 1990)	$K_{oc} = 79 \frac{\text{mL}}{\text{gm}}$	
Bulk density (Freeze and Cherry, 1979)	$\rho_b = 1.65 \frac{\text{gm}}{\text{cm}^3}$	
Organic carbon content	$f_{oc} = 0.06 \%$	
Retardation coefficient	$R = 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$	$R = 1.261$

Groundwater Hydraulics Calculations

Groundwater velocity (pore-water)	$v_x = \frac{K \cdot I}{n_e}$	$v_x = 0.664 \frac{\text{m}}{\text{day}}$
Contaminant velocity	$v_c = \frac{v_x}{R}$	$v_c = 0.527 \frac{\text{m}}{\text{day}}$
Longitudinal dispersion coefficient	$D_x = \alpha_x \cdot v_x$	$D_x = 214.404 \frac{\text{ft}^2}{\text{day}}$

110 Meters Downgradient from the Highest Observed Benzene Concentration

Initial Plume Distribution Calculation

year = 365 day $t_i = 1..120$

$x := 110 \cdot m$

$\Delta t := 1 \cdot year$

$t_i := \Delta t \cdot i$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

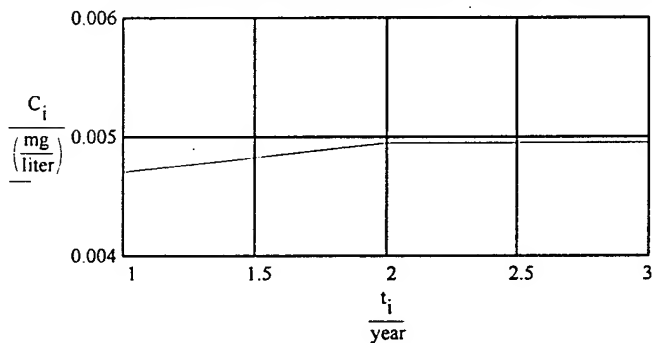
$$C_i = C_0 \cdot \exp(-\lambda \cdot t_i) \cdot \left[1 - \frac{1}{2} \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x - v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) - \left(\frac{v_x^2 \cdot t_i}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x - v_x \cdot t_i)^2}{4 \cdot D_x \cdot R \cdot t_i} \right] + \frac{1}{2} \cdot \left(1 + \frac{v_x \cdot x}{D_x} + \frac{v_x^2 \cdot t_i}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x + v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t_i) \cdot \left[\frac{v_x}{v_x + v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x - v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x - t_i \cdot v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right] \dots \right.$$

$$+ \left[\frac{v_x}{v_x - v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x + v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x + t_i \cdot v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x}{D_x} - (\lambda - \gamma) \cdot t_i \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x + v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) \right]$$

Concentration of Benzene (mg/L) versus Time (years)



**Transient Solution to the Advective-Dispersive Equation for One-Dimensional Flow,
Type Three Boundary Condition (0.200 mg/L chlorobenzene source with no decay,
with a 0.010 day⁻¹ anaerobic decay coefficient, Constant Time, Variable Location)**

Hydrogeologic Data

Hydraulic conductivity	$K := 30.18 \cdot \frac{\text{m}}{\text{day}}$
Hydraulic gradient	$I := 0.0055 \cdot \frac{\text{ft}}{\text{ft}}$
Effective porosity	$n_e := 0.25$
Total porosity	$n := 0.3$
Longitudinal dispersivity	$\alpha_x := 30 \cdot \text{m}$
Concentration of Injected Contaminant	$C_s := 0.200 \cdot \frac{\text{mg}}{\text{liter}}$
Initial Dissolved Contaminant Concentration	$C_o := 0 \cdot \frac{\text{mg}}{\text{liter}}$

Retardation Coefficient Calculation

Solute Decay Rate	$\lambda := 0.010 \cdot \frac{1}{\text{day}}$	
Source Decay Rate	$\gamma := 0.00000 \cdot \frac{1}{\text{day}}$	
Soil sorption coefficient (EPA, 1990)	$K_{oc} := 79 \cdot \frac{\text{mL}}{\text{gm}}$	
Bulk density (Freeze and Cherry, 1979)	$\rho_b := 1.65 \cdot \frac{\text{gm}}{\text{cm}^3}$	
Organic carbon content	$f_{oc} := 0.06 \cdot \%$	
Retardation coefficient	$R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$	$R = 1.261$

Groundwater Hydraulics Calculations

Groundwater velocity (pore-water)	$v_x := \frac{K \cdot I}{n_e}$	$v_x = 0.664 \cdot \frac{\text{m}}{\text{day}}$
Contaminant velocity	$v_c := \frac{v_x}{R}$	$v_c = 0.527 \cdot \frac{\text{m}}{\text{day}}$
Longitudinal dispersion coefficient	$D_x := \alpha_x \cdot v_x$	$D_x = 214.404 \cdot \frac{\text{ft}^2}{\text{day}}$

Initial Plume Distribution Calculation

$$j = 0..3000 \quad t := 730 \text{ day}$$

$$\Delta x := 1 \text{ m}$$

$$x_j := \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

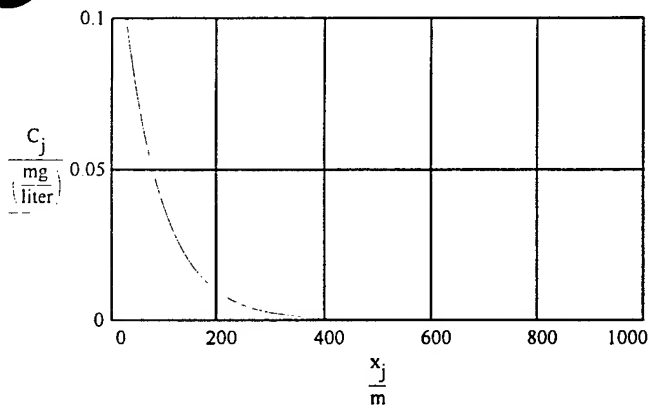
$$C_j = C_o \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \cdot \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x - v_x'}{2 \cdot D_x} \cdot \left(1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma) \right) \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots \right.$$

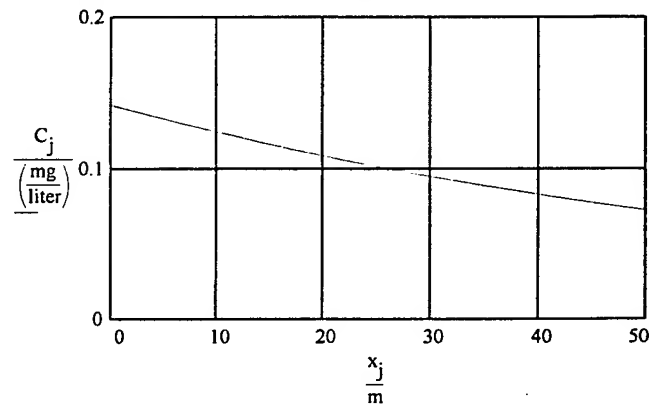
$$+ \left[\frac{v_x}{v_x - v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x + v_x'}{2 \cdot D_x} \cdot \left(1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma) \right) \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right]$$

Dissolved Chlorobenzene (mg/L) Concentration versus Distance (m)



Dissolved Chlorobenzene (mg/L) Concentration versus Distance



**Transient Solution to the Advective-Dispersive Equation for One-Dimensional Flow,
Type Three Boundary Condition (0.200 mg/L chlorobenzene source with no decay, a
0.010 day⁻¹ anaerobic decay coefficient, Constant Location, Variable Time)**

Hydrogeologic Data

Hydraulic conductivity	$K := 30.18 \frac{\text{m}}{\text{day}}$
Hydraulic gradient	$I := 0.0055 \frac{\text{ft}}{\text{ft}}$
Effective porosity	$n_e := 0.25$
Total porosity	$n := 0.3$
Longitudinal dispersivity (EPRI, 1985)	$\alpha_x := 30 \cdot \text{m}$
Concentration of Injected Contaminant	$C_s := 0.200 \frac{\text{mg}}{\text{liter}}$
Initial Dissolved Contaminant Concentration	$C_o := 0 \frac{\text{mg}}{\text{liter}}$

Retardation Coefficient Calculation

Solute Decay Rate	$\lambda := 0.01 \frac{1}{\text{day}}$
Source Decay Rate	$\gamma := 0.00000 \frac{1}{\text{day}}$

Soil sorption coefficient (EPA, 1990)	$K_{oc} := 79 \frac{\text{mL}}{\text{gm}}$
---------------------------------------	--

Bulk density (Freeze and Cherry, 1979)	$\rho_b := 1.65 \frac{\text{gm}}{\text{cm}^3}$
--	--

Organic carbon content	$f_{oc} := 0.06 \cdot \%$
------------------------	---------------------------

Retardation coefficient	$R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$	$R = 1.261$
-------------------------	---	-------------

Groundwater Hydraulics Calculations

Groundwater velocity (pore-water)	$v_x := \frac{K \cdot I}{n_e}$	$v_x = 0.664 \frac{\text{m}}{\text{day}}$
-----------------------------------	--------------------------------	---

Contaminant velocity	$v_c := \frac{v_x}{R}$	$v_c = 0.527 \frac{\text{m}}{\text{day}}$
----------------------	------------------------	---

Longitudinal dispersion coefficient	$D_x := \alpha_x \cdot v_x$	$D_x = 214.404 \frac{\text{ft}^2}{\text{day}}$
-------------------------------------	-----------------------------	--

30 Meters Downgradient from Highest Observed Chlorobenzene Concentration

Initial Plume Distribution Calculation

$$\text{year} = 365 \cdot \text{day} \quad i = 1..120$$

$$x = 30 \cdot \text{m}$$

$$\Delta t = 1 \cdot \text{year}$$

$$t_i = \Delta t \cdot i$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

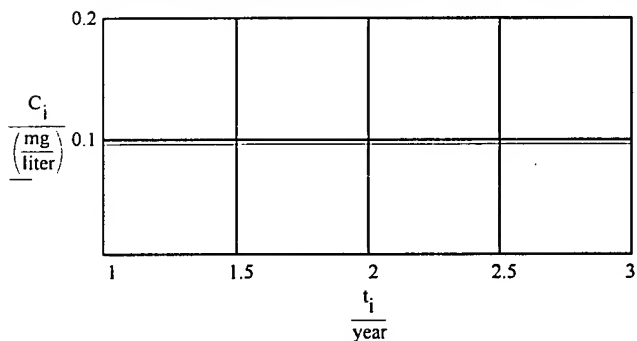
$$C_i = C_0 \cdot \exp(-\lambda \cdot t_i) \cdot \left[1 - \frac{1}{2} \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x - v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) - \frac{v_x^2 \cdot t_i}{\pi \cdot D_x \cdot R} \cdot \exp \left[-\frac{(R \cdot x - v_x \cdot t_i)^2}{4 \cdot D_x \cdot R \cdot t_i} \right] + \frac{1}{2} \cdot \left(1 + \frac{v_x \cdot x}{D_x} + \frac{v_x^2 \cdot t_i}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x + v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t_i) \cdot \left[\frac{v_x}{v_x + v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x - v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x - t_i \cdot v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right] \dots \right.$$

$$+ \left[\frac{v_x}{v_x - v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x + v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x + t_i \cdot v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right] \dots \right.$$

$$\left. + \frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x \cdot x}{D_x} - (\lambda - \gamma) \cdot t_i \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x + v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) \right]$$

Concentration of Chlorobenzene (mg/L) versus Time (years)



**Transient Solution to the Advective-Dispersive Equation for One-Dimensional Flow,
Type Three Boundary Condition (0.0075 mg/L TCE source with no decay, with a
0.0035 day-1 reductive dehalogenation coefficient, Constant Time, Variable Location)**

Hydrogeologic Data

Hydraulic conductivity	$K := 30.18 \cdot \frac{\text{m}}{\text{day}}$
Hydraulic gradient	$I := 0.0055 \cdot \frac{\text{ft}}{\text{ft}}$
Effective porosity	$n_e := 0.25$
Total porosity	$n := 0.3$
Longitudinal dispersivity	$\alpha_x := 30 \cdot \text{m}$
Concentration of Injected Contaminant	$C_s := 0.0075 \cdot \frac{\text{mg}}{\text{liter}}$
Initial Dissolved Contaminant Concentration	$C_o := 0 \cdot \frac{\text{mg}}{\text{liter}}$

Retardation Coefficient Calculation

Solute Decay Rate	$\lambda := 0.0035 \cdot \frac{1}{\text{day}}$	
Source Decay Rate	$\gamma := 0.00000 \cdot \frac{1}{\text{day}}$	
Soil sorption coefficient (EPA, 1990)	$K_{oc} := 72 \cdot \frac{\text{mL}}{\text{gm}}$	
Bulk density (Freeze and Cherry, 1979)	$\rho_b := 1.65 \cdot \frac{\text{gm}}{\text{cm}^3}$	
Organic carbon content	$f_{oc} := 0.06 \cdot \%$	
Retardation coefficient	$R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$	$R = 1.238$

Groundwater Hydraulics Calculations

Groundwater velocity (pore-water)	$v_x := \frac{K \cdot I}{n_e}$	$v_x = 0.664 \cdot \frac{\text{m}}{\text{day}}$
Contaminant velocity	$v_c := \frac{v_x}{R}$	$v_c = 0.536 \cdot \frac{\text{m}}{\text{day}}$
Longitudinal dispersion coefficient	$D_x := \alpha_x \cdot v_x$	$D_x = 214.404 \cdot \frac{\text{ft}^2}{\text{day}}$

Initial Plume Distribution Calculation

$$j := 0..3000$$

$$t := 730 \cdot \text{day}$$

$$\Delta x = 1 \cdot \text{m}$$

$$x_j = \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

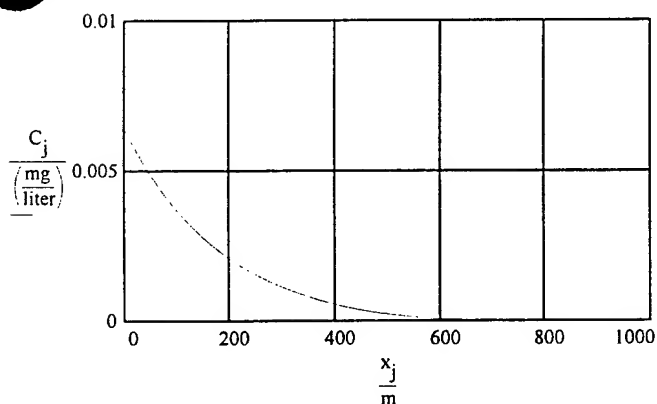
$$C_j = C_0 \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x'} \cdot \exp \left[\frac{v_x - v_x'}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j \right] \cdot \left(1 - \operatorname{erf} \left[\frac{R \cdot x_j - t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \right) \right] \dots$$

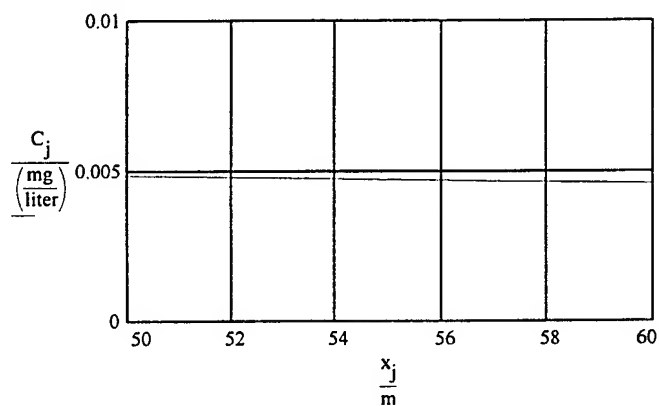
$$+ \left[\frac{v_x}{v_x - v_x'} \cdot \exp \left[\frac{v_x + v_x'}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j \right] \cdot \left(1 - \operatorname{erf} \left[\frac{R \cdot x_j + t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \right) \right] \dots$$

$$+ \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right)$$

Dissolved TCE (mg/L) Concentration versus Distance (m)



Dissolved TCE (mg/L) Concentration versus Distance (m)



**Transient Solution to the Advective-Dispersive Equation for One-Dimensional Flow,
Type Three Boundary Condition (0.0075 mg/L TCE source with no decay, a 0.0035
day-1 reductive dehalogenation decay coefficient, Constant Location, Variable Time)**

Hydrogeologic Data

Hydraulic conductivity	$K := 30.18 \cdot \frac{\text{m}}{\text{day}}$
Hydraulic gradient	$I := 0.0055 \cdot \frac{\text{ft}}{\text{ft}}$
Effective porosity	$n_e := 0.25$
Total porosity	$n := 0.3$
Longitudinal dispersivity (EPRI, 1985)	$\alpha_x := 30 \cdot \text{m}$
Concentration of Injected Contaminant	$C_s := 0.0075 \cdot \frac{\text{mg}}{\text{liter}}$
Initial Dissolved Contaminant Concentration	$C_o := 0 \cdot \frac{\text{mg}}{\text{liter}}$

Retardation Coefficient Calculation

Solute Decay Rate	$\lambda := 0.0035 \cdot \frac{1}{\text{day}}$	
Source Decay Rate	$\gamma := 0.00000 \cdot \frac{1}{\text{day}}$	
Soil sorption coefficient (EPA, 1990)	$K_{oc} := 72 \cdot \frac{\text{mL}}{\text{gm}}$	
Bulk density (Freeze and Cherry, 1979)	$\rho_b := 1.65 \cdot \frac{\text{gm}}{\text{cm}^3}$	
Organic carbon content	$f_{oc} := 0.06 \cdot \%$	
Retardation coefficient	$R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$	$R = 1.238$

Groundwater Hydraulics Calculations

Groundwater velocity (pore-water)	$v_x := \frac{K \cdot I}{n_e}$	$v_x = 0.664 \cdot \frac{\text{m}}{\text{day}}$
Contaminant velocity	$v_c := \frac{v_x}{R}$	$v_c = 0.536 \cdot \frac{\text{m}}{\text{day}}$
Longitudinal dispersion coefficient	$D_x := \alpha_x \cdot v_x$	$D_x = 214.404 \cdot \frac{\text{ft}^2}{\text{day}}$

65 Meters Downgradient from Highest Observed TCE Concentration

Initial Plume Distribution Calculation

$$\text{year} = 365 \cdot \text{day} \quad i = 1 \dots 120$$

$$x = 50 \cdot \text{m}$$

$$\Delta t = 1 \cdot \text{year}$$

$$t_i = \Delta t \cdot i$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

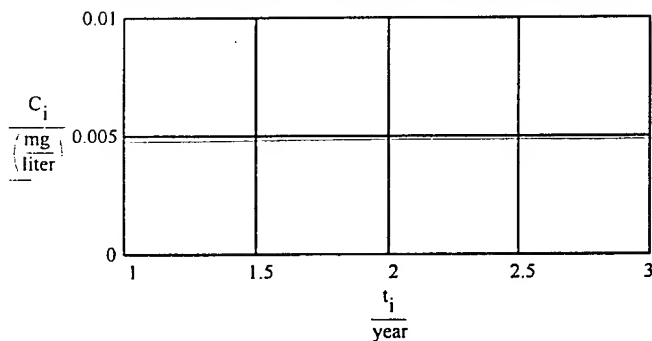
$$C_i = C_o \cdot \exp(-\lambda \cdot t_i) \cdot \left[1 - \frac{1}{2} \left(1 - \operatorname{erf} \left(\frac{R \cdot x - v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) - \left(\frac{v_x^2 \cdot t_i}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x - v_x \cdot t_i)^2}{4 \cdot D_x \cdot R \cdot t_i} \right] + \frac{1}{2} \left(1 + \frac{v_x \cdot x}{D_x} + \frac{v_x^2 \cdot t_i}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x + v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t_i) \cdot \left[\frac{v_x}{v_x + v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x - v_x'}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x - t_i \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots$$

$$+ \left[\frac{v_x}{v_x - v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x + v_x'}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x + t_i \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots$$

$$+ \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x}{D_x} - (\lambda - \gamma) \cdot t_i \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x + v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right) \right)$$

Concentration of TCE (mg/L) versus Time (years)



**Transient Solution to the Advective-Dispersive Equation for One-Dimensional Flow,
Type Three Boundary Condition (0.010 mg/L VC source with no decay, with a 0.0035
day⁻¹ reductive dehalogenation decay coefficient, Constant Time, Variable Location)**

Hydrogeologic Data

Hydraulic conductivity	$K := 30.18 \cdot \frac{\text{m}}{\text{day}}$
Hydraulic gradient	$I := 0.0055 \cdot \frac{\text{ft}}{\text{ft}}$
Effective porosity	$n_e := 0.25$
Total porosity	$n := 0.3$
Longitudinal dispersivity	$\alpha_x := 30 \cdot \text{m}$
Concentration of Injected Contaminant	$C_s := 0.010 \cdot \frac{\text{mg}}{\text{liter}}$
Initial Dissolved Contaminant Concentration	$C_o := 0 \cdot \frac{\text{mg}}{\text{liter}}$

Retardation Coefficient Calculation

Solute Decay Rate	$\lambda := 0.0035 \cdot \frac{1}{\text{day}}$	
Source Decay Rate	$\gamma := 0.00000 \cdot \frac{1}{\text{day}}$	
Soil sorption coefficient (EPA, 1990)	$K_{oc} := 2.45 \cdot \frac{\text{mL}}{\text{gm}}$	
Bulk density (Freeze and Cherry, 1979)	$\rho_b := 1.65 \cdot \frac{\text{gm}}{\text{cm}^3}$	
Organic carbon content	$f_{oc} := 0.06 \cdot \%$	
Retardation coefficient	$R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$	$R = 1.008$

Groundwater Hydraulics Calculations

Groundwater velocity (pore-water)	$v_x := \frac{K \cdot I}{n_e}$	$v_x = 0.664 \cdot \frac{\text{m}}{\text{day}}$
Contaminant velocity	$v_c := \frac{v_x}{R}$	$v_c = 0.659 \cdot \frac{\text{m}}{\text{day}}$
Longitudinal dispersion coefficient	$D_x = \alpha_x \cdot v_x$	$D_x = 214.404 \cdot \frac{\text{ft}^2}{\text{day}}$

Initial Plume Distribution Calculation

$$j = 0..3000$$

$$t = 730 \text{ day}$$

$$\Delta x = 1 \text{ m}$$

$$x_j = \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

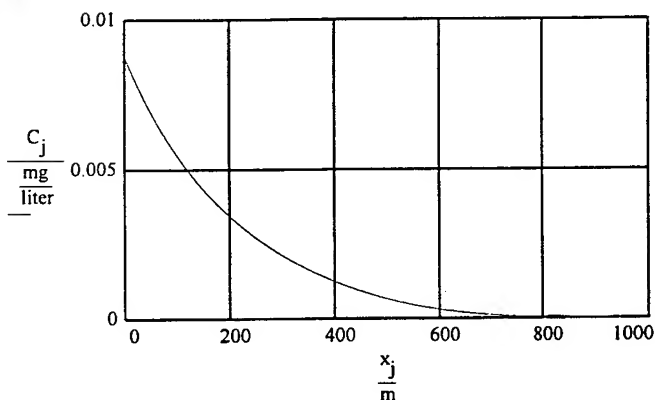
$$C_j = C_0 \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \cdot 1 - \operatorname{erf} \frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} - \frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \cdot \exp \left[-\frac{R \cdot x_j - v_x \cdot t^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \cdot 1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \cdot \exp \frac{v_x \cdot x_j}{D_x} \cdot 1 - \operatorname{erf} \frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x_j \right] \cdot 1 - \operatorname{erf} \left[\frac{R \cdot x_j - t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right] \dots \right.$$

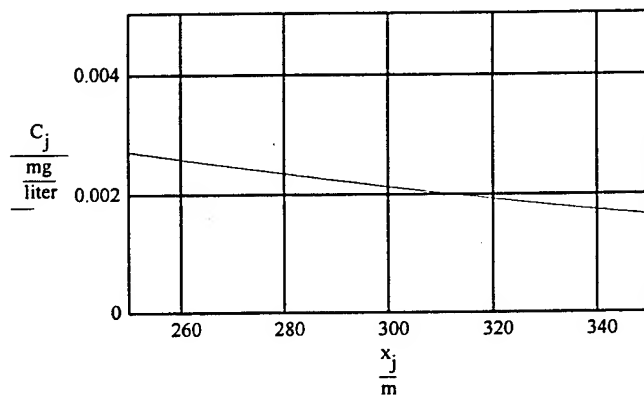
$$+ \left[\frac{v_x}{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x_j \right] \cdot 1 - \operatorname{erf} \left[\frac{R \cdot x_j + t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot 1 - \operatorname{erf} \frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right] \dots \right]$$

Dissolved VC (mg/L) Concentration versus Distance (m)



Dissolved VC (mg/L) Concentration versus Distance (m)



**Transient Solution to the Advective-Dispersive Equation for One-Dimensional Flow,
Type Three Boundary Condition (0.010 mg/L VC source with no decay, a 0.0035 day⁻¹
reductive dehalogenation decay coefficient, Constant Location, Variable Time)**

Geologic Data

Hydraulic conductivity	$K := 30.18 \frac{\text{m}}{\text{day}}$
Hydraulic gradient	$I := 0.0055 \frac{\text{ft}}{\text{ft}}$
Effective porosity	$n_e := 0.25$
Total porosity	$n := 0.3$
Longitudinal dispersivity (EPRI, 1985)	$\alpha_x := 30 \text{ m}$
Concentration of Injected Contaminant	$C_s := 0.010 \frac{\text{mg}}{\text{liter}}$
Initial Dissolved Contaminant Concentration	$C_o := 0 \frac{\text{mg}}{\text{liter}}$

Retardation Coefficient Calculation

Solute Decay Rate	$\lambda := 0.0035 \frac{1}{\text{day}}$
Source Decay Rate	$\gamma := 0.00000 \frac{1}{\text{day}}$
Distribution coefficient (EPA, 1990)	$K_{oc} := 2.45 \frac{\text{mL}}{\text{gm}}$

Bulk density (Freeze and Cherry, 1979)	$\rho_b := 1.65 \frac{\text{gm}}{\text{cm}^3}$
Organic carbon content	$f_{oc} := 0.06 \%$
Retardation coefficient	$R := 1 + \frac{\rho_b \cdot K_{oc} \cdot f_{oc}}{n}$ $R = 1.008$

Groundwater Hydraulics Calculations

Groundwater velocity (pore-water)	$v_x := \frac{K \cdot I}{n_e}$ $v_x = 0.664 \frac{\text{m}}{\text{day}}$
Contaminant velocity	$v_c := \frac{v_x}{R}$ $v_c = 0.659 \frac{\text{m}}{\text{day}}$
Longitudinal dispersion coefficient	$D_x := \alpha_x \cdot v_x$ $D_x = 214.404 \frac{\text{ft}^2}{\text{day}}$

310 meter downgradient from the source area

Initial Plume Distribution Calculation

$$\text{year} := 365 \cdot \text{day} \quad i := 1..120$$

$$x := 310 \cdot \text{m}$$

$$\Delta t := 1 \cdot \text{year}$$

$$t_i := \Delta t \cdot i$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

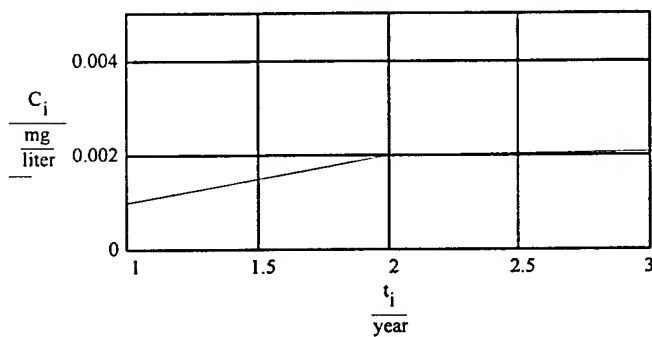
$$C_i = C_0 \cdot \exp(-\lambda \cdot t_i) \cdot \left[1 - \frac{1}{2} \cdot 1 - \operatorname{erf} \frac{R \cdot x - v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} - \frac{v_x^2 \cdot t_i}{\pi \cdot D_x \cdot R} \cdot \exp \left[-\frac{R \cdot x - v_x \cdot t_i}{4 \cdot D_x \cdot R \cdot t_i} \right] + \frac{1}{2} \cdot 1 + \frac{v_x \cdot x}{D_x} + \frac{v_x^2 \cdot t_i}{D_x \cdot R} \cdot \exp \frac{v_x \cdot x}{D_x} \cdot 1 - \operatorname{erf} \frac{R \cdot x + v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t_i) \cdot \left[\frac{v_x}{v_x + v_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x - v_x}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x \right] \cdot \left[1 - \operatorname{erf} \left[\frac{R \cdot x - t_i \cdot v_x}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \right] \dots$$

$$+ \left[\frac{v_x}{v_x - v_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x + v_x}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x \right] \cdot \left[1 - \operatorname{erf} \left[\frac{R \cdot x + t_i \cdot v_x}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \right] \dots$$

$$+ \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x}{D_x} - (\lambda - \gamma) \cdot t_i \right] \cdot 1 - \operatorname{erf} \frac{R \cdot x + v_x \cdot t_i}{2 \cdot \sqrt{D_x \cdot R \cdot t_i}}$$

Concentration of BTEX (mg/L) versus Time (years)



Sensitivity Analysis of Hydraulic Conductivity (2 times less than observed value)

Initial Plume Distribution Calculation

$$j := 0..3000$$

$$t := 730 \text{ day}$$

$$\Delta x := 1 \text{ m}$$

$$x_j := \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

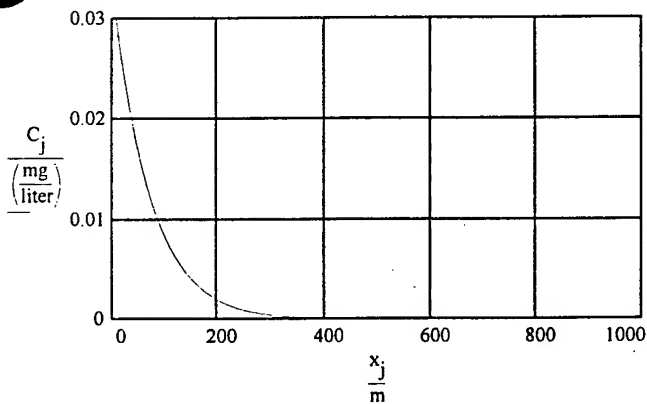
$$C_j = C_o \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \cdot \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x - v_x'}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots$$

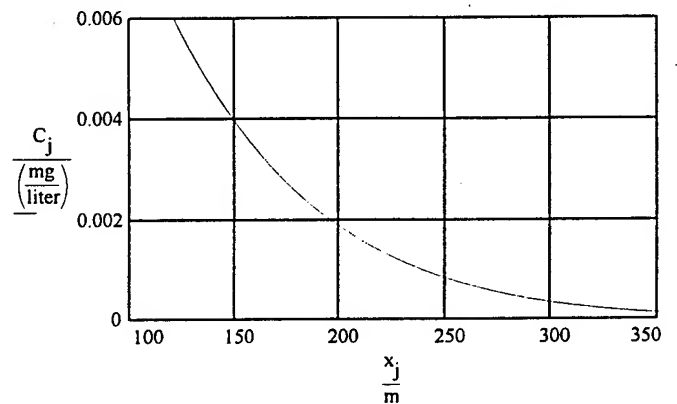
$$+ \left[\frac{v_x}{v_x - v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x + v_x'}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots$$

$$+ \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right)$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



Sensitivity Analysis of Hydraulic Conductivity (2 times greater than observed value)

Initial Plume Distribution Calculation

$$j = 0..3000$$

$$t = 730 \text{ day}$$

$$\Delta x = 1 \text{ m}$$

$$x_j = \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

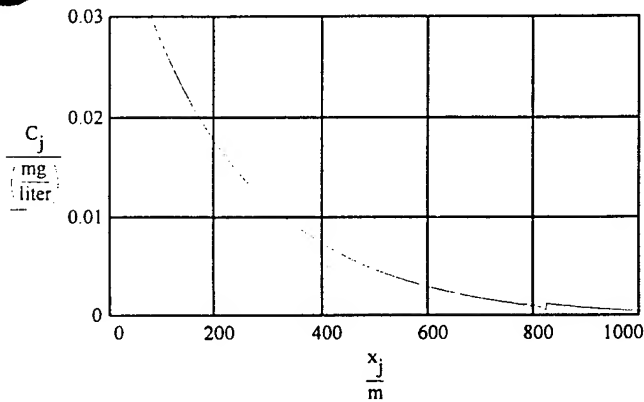
$$C_j = C_0 \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots \right.$$

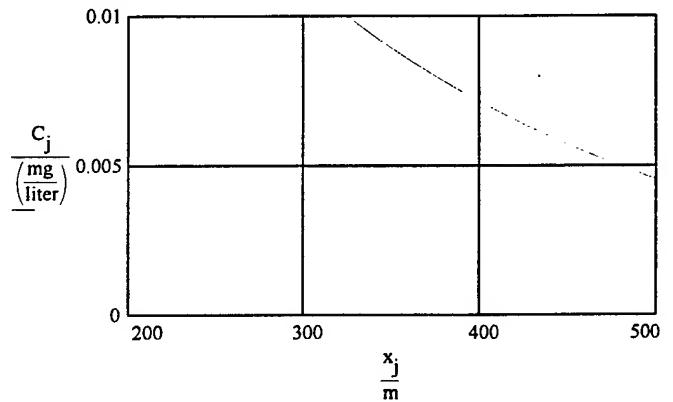
$$+ \left[\frac{v_x}{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right]$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



Sensitivity Analysis of Effective Porosity (25 percent more than observed value)

Initial Plume Distribution Calculation

$$j = 0..3000$$

$$t := 730 \text{ day}$$

$$\Delta x = 1 \text{ m}$$

$$x_j = \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

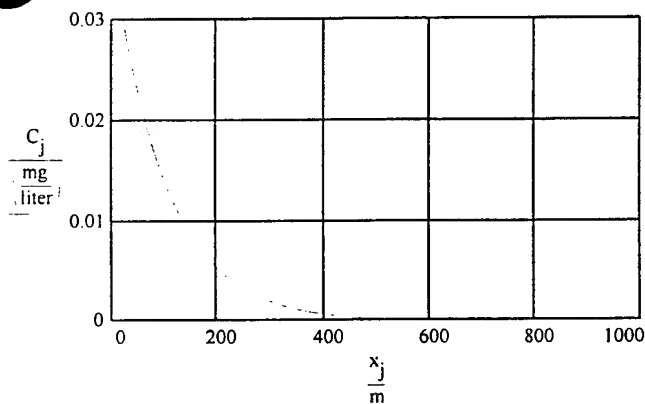
$$C_j = C_o \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x - v_x'}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots \right.$$

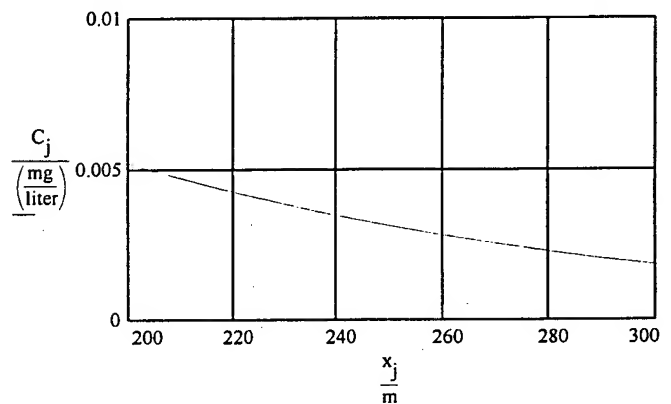
$$+ \left[\frac{v_x}{v_x - v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x + v_x'}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right]$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



Sensitivity Analysis of Effective Porosity (25 percent less than observed value)

Initial Plume Distribution Calculation

$$j = 0..3000$$

$$t = 730 \text{ day}$$

$$\Delta x = 1 \text{ m}$$

$$x_j = \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

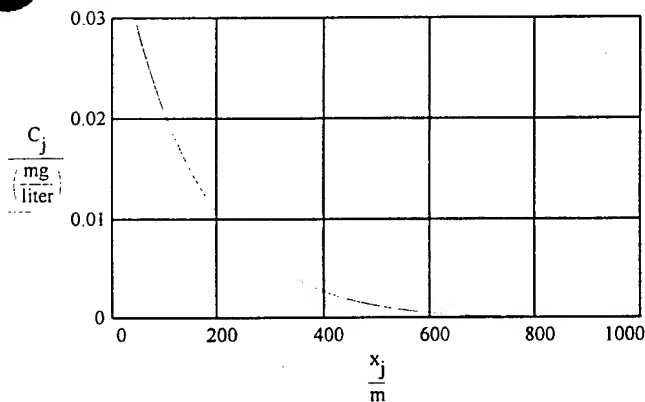
$$C_j = C_0 \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \cdot \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x - v_x'}{2 \cdot D_x} \cdot \left(1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma) \right) \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots \right.$$

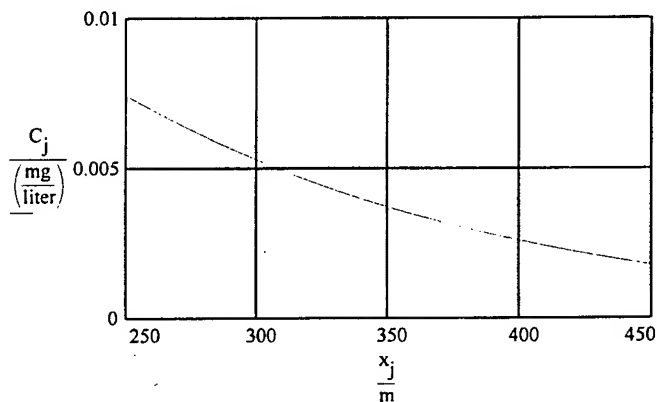
$$+ \left[\frac{v_x}{v_x - v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x + v_x'}{2 \cdot D_x} \cdot \left(1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma) \right) \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right]$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



Sensitivity Analysis of Solute Decay (2 times greater than calculated value)

Initial Plume Distribution Calculation

$$j = 0 \dots 3000$$

$$t = 730 \text{ day}$$

$$\Delta x = 1 \text{ m}$$

$$x_j = \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

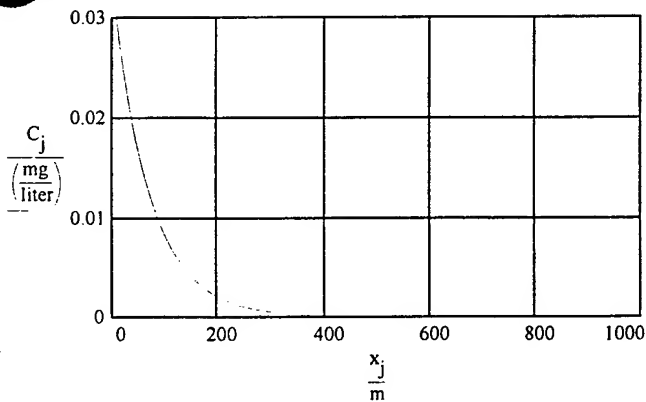
$$C_j = C_0 \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \cdot \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x - v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j}{2 \cdot D_x} \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots$$

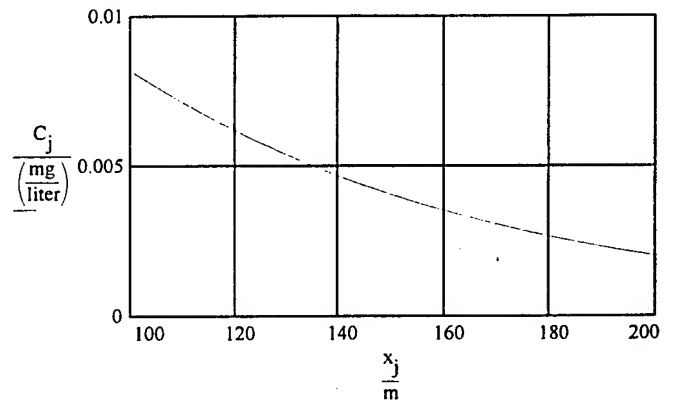
$$+ \left[\frac{v_x}{v_x - v_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x + v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j}{2 \cdot D_x} \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots$$

$$+ \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right)$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



Sensitivity Analysis of Solute Decay (2 times less than calculated value)

Initial Plume Distribution Calculation

$$j = 0..3000$$

$$t = 730 \text{ day}$$

$$\Delta x = 1 \text{ m}$$

$$x_j = \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

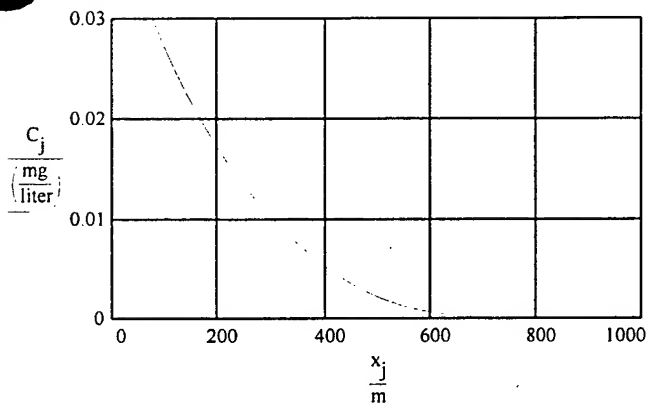
$$C_j = C_0 \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x - v_x'}{2 \cdot D_x} \cdot \left(1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma) \right) \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots \right.$$

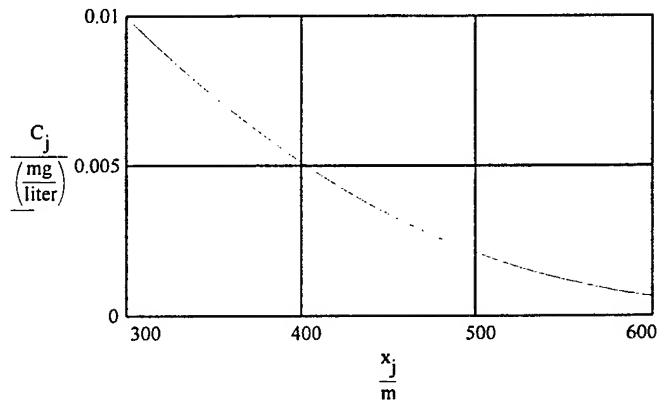
$$+ \left[\frac{v_x}{v_x - v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x + v_x'}{2 \cdot D_x} \cdot \left(1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma) \right) \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right]$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



Sensitivity Analysis of Total Organic Carbon Content (2 times more than observed value)

Initial Plume Distribution Calculation

$$j = 0..3000$$

$$t = 730 \text{ day}$$

$$\Delta x = 1 \text{ m}$$

$$x_j = \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

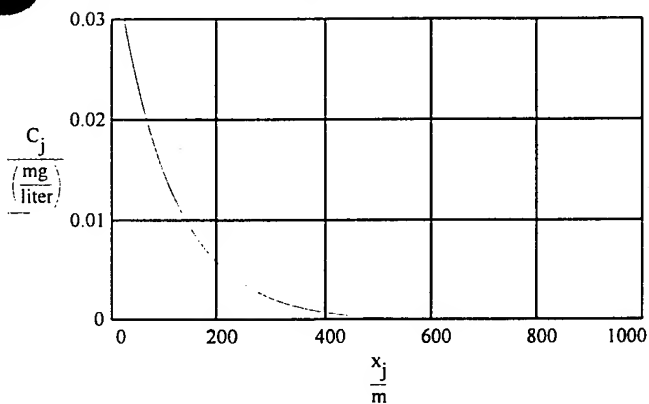
$$C_j = C_0 \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \cdot 1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \cdot \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x - v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x - v_x'}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots \right.$$

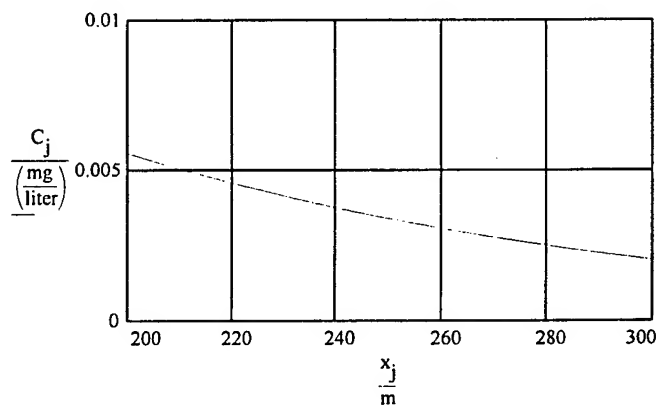
$$+ \left[\frac{v_x}{v_x - v_x'} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x + v_x'}{2 \cdot D_x} \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots \right.$$

$$+ \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right)$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



Sensitivity Analysis of Total Organic Carbon Content (2 times less than observed value)

Initial Plume Distribution Calculation

$$j = 0..3000$$

$$t = 730 \text{ day}$$

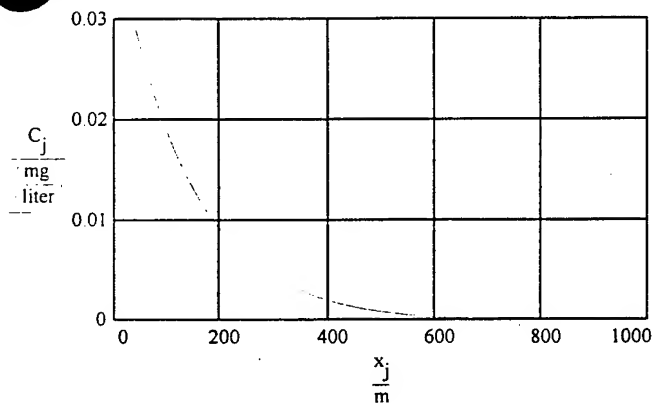
$$\Delta x = 1 \text{ m}$$

$$x_j = \Delta x \cdot j$$

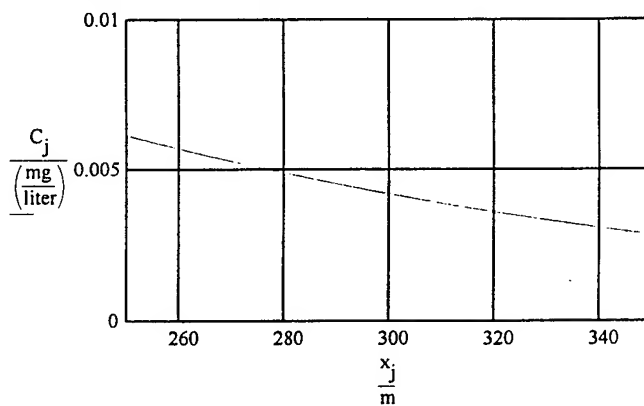
For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

$$C_j = C_o \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \cdot \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \right] \\ + C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j}{2 \cdot D_x} \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \right] \\ + \left[\frac{v_x}{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j}{2 \cdot D_x} \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \right] \\ + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} \right] - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right)$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



Sensitivity Analysis of Dispersivity (2 times greater than observed value)

Initial Plume Distribution Calculation

$$j = 0 \dots 3000$$

$$t = 730 \text{ day}$$

$$\Delta x = 1 \text{ m}$$

$$x_j = \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

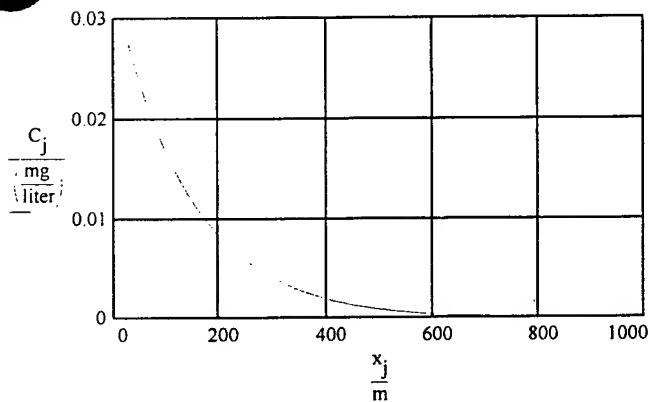
$$C_j = C_0 \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x'} \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x - v_x'}{2 \cdot D_x} \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots \right.$$

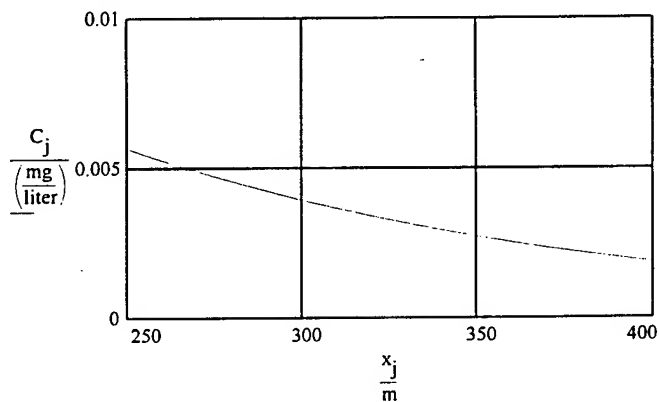
$$+ \left[\frac{v_x}{v_x - v_x'} \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot \exp \left[\frac{v_x + v_x'}{2 \cdot D_x} \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x'}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)} \right) \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right]$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



Sensitivity Analysis of Dispersivity (2 times greater than observed value)

Initial Plume Distribution Calculation

$$j = 0..3000$$

$$t = 730 \text{ day}$$

$$\Delta x = 1 \text{ m}$$

$$x_j = \Delta x \cdot j$$

For Retarded Flow with Biodegradation and a Decaying Source (van Genuchten and Alves, 1982)

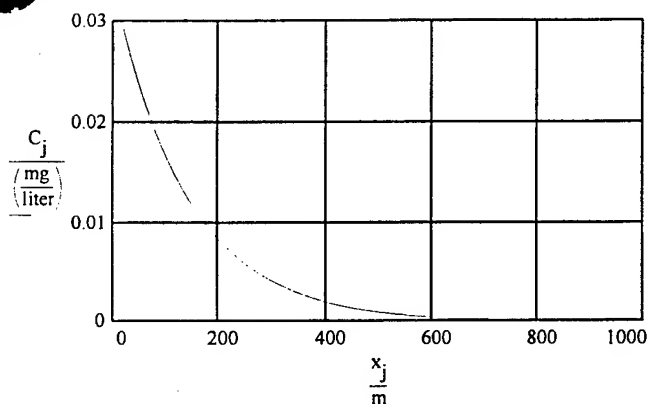
$$C_j = C_0 \cdot \exp(-\lambda \cdot t) \cdot \left[1 - \frac{1}{2} \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j - v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) - \left(\frac{v_x^2 \cdot t}{\pi \cdot D_x \cdot R} \right) \cdot \exp \left[-\frac{(R \cdot x_j - v_x \cdot t)^2}{4 \cdot D_x \cdot R \cdot t} \right] + \frac{1}{2} \cdot \left(1 + \frac{v_x \cdot x_j}{D_x} + \frac{v_x^2 \cdot t}{D_x \cdot R} \right) \cdot \exp \left(\frac{v_x \cdot x_j}{D_x} \right) \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right] \dots$$

$$+ C_s \cdot \exp(-\gamma \cdot t) \cdot \left[\frac{v_x}{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j - t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots \right.$$

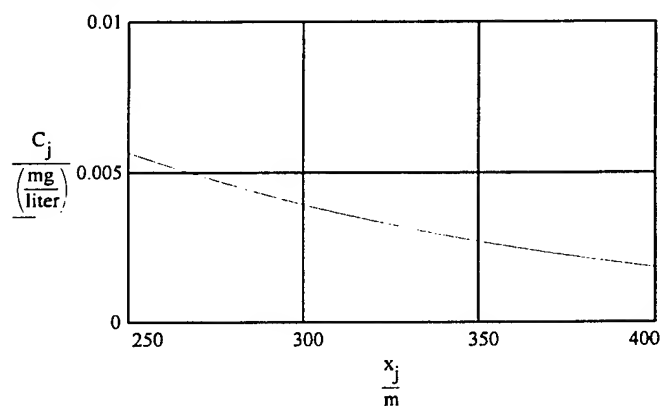
$$+ \left[\frac{v_x}{v_x - v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}} \cdot \exp \left[\frac{v_x + v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot D_x} \cdot x_j \right] \cdot \left[1 - \operatorname{erf} \left(\frac{R \cdot x_j + t \cdot v_x' \cdot \sqrt{1 + \frac{4 \cdot D_x \cdot R}{v_x^2} \cdot (\lambda - \gamma)}}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right] \dots \right.$$

$$\left. + \left[\frac{v_x^2}{2 \cdot D_x \cdot R \cdot (\lambda - \gamma)} \right] \cdot \exp \left[\frac{v_x \cdot x_j}{D_x} - (\lambda - \gamma) \cdot t \right] \cdot \left(1 - \operatorname{erf} \left(\frac{R \cdot x_j + v_x \cdot t}{2 \cdot \sqrt{D_x \cdot R \cdot t}} \right) \right) \right]$$

Dissolved BTEX (mg/L) Concentration versus Distance (m)



Dissolved BTEX (mg/L) Concentration versus Distance (m)



APPENDIX D
COST ESTIMATE CALCULATIONS

Present Worth Analysis

Annual Adjustment Factor = 7%

Alternative 1: Natural Attenuation with Institutional Controls and Long-Term Groundwater Monitoring		Present Worth	Cost (\$) at Year Indicated									
years		(\$)	Year: 1	2	3	4	5	6	7	8	9	10
Maintain Institutional Controls	10	\$35,118	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000
Long-term Monitoring												
Install New Wells	1	\$19,814	\$21,201	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groundwater Sampling (annual)	10	\$94,362	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435
Groundwater Sampling (every other year)	0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Reporting/Project Mgmt (annual)	10	\$33,341	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747
Subtotal Present Worth (\$)		\$182,635										

Total Present Worth Cost (\$): \$182,635

Present Worth Analysis

Annual Adjustment Factor = 7%

Alternative 2: Natural Attenuation and Sparging System with Institutional Controls and Long-Term Monitoring		Present Worth	Cost (\$) at Year Indicated									
years		(\$)	Year: 1	2	3	4	5	6	7	8	9	10
Sparging System												
System Installation	1	\$234,925	\$251,370	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
System Maintenance	10	\$357,079	\$50,840	\$50,840	\$50,840	\$50,840	\$50,840	\$50,840	\$50,840	\$50,840	\$50,840	\$50,840
Annual Report	10	\$39,866	\$5,676	\$5,676	\$5,676	\$5,676	\$5,676	\$5,676	\$5,676	\$5,676	\$5,676	\$5,676
Subtotal Present Worth (\$)		\$631,870										
Maintain Institutional Controls	10	\$35,118	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000
Long-term Monitoring												
Install New Wells	1	\$19,814	\$21,201	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groundwater Sampling (annual)	10	\$94,362	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435
Groundwater Sampling (every other year)	0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Reporting/Project Mgmt (annual)	10	\$33,341	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747
Subtotal Present Worth (\$)		\$182,635										

Total Present Worth Cost (\$): \$814,505

Present Worth Analysis

Annual Adjustment Factor = 7%

Alternative 3: Natural Attenuation and Groundwater Extraction and Treatment with Institutional Controls and Long-Term Monitoring		Present Worth	Cost (\$) at Year Indicated									
years		(\$)	Year: 1	2	3	4	5	6	7	8	9	10
Groundwater Pump and Treat System												
System Installation	1	\$396,735	\$424,507	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
System Maintenance	5	\$239,206	\$58,340	\$58,340	\$58,340	\$58,340	\$58,340	\$0	\$0	\$0	\$0	\$0
Annual Report	5	\$30,772	\$7,505	\$7,505	\$7,505	\$7,505	\$7,505	\$0	\$0	\$0	\$0	\$0
Subtotal Present Worth (\$)		\$666,713										
Maintain Institutional Controls	10	\$35,118	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000
Long-term Monitoring												
Install New Wells	1	\$19,814	\$21,201	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groundwater Sampling (annual)	10	\$94,362	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435	\$13,435
Groundwater Sampling (every other year)	0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Reporting/Project Mgmt (annual)	10	\$33,341	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747	\$4,747
Subtotal Present Worth (\$)		\$182,635										

Total Present Worth Cost (\$): \$849,348

Alternatives 1, 2, and 3: Long-Term Monitoring and Institutional Controls
Standard Rate Schedule

Billing Category	Billing Rate	Task 1 (hrs)	Install New LTM/POC Wells (\$)	Task 2 (hrs)	Sampling (\$)	Task 3 (hrs)	Reporting & PM (\$)
Word Processor 88/(15)	\$30	0	\$0	0	\$0	8	\$240
CADD Operator 58/(25)	\$47	4	\$188	0	\$0	16	\$752
Technician 42/(50)	\$40	10	\$400	30	\$1,200	10	\$400
Staff Level 16/(65)	\$57	80	\$4,560	30	\$1,710	20	\$1,140
Project Level 12/(70)	\$65	4	\$260	4	\$260	10	\$650
Senior Level 10/(80)	\$85	1	\$85	0	\$0	3	\$255
Principal 02/(85)	\$97	0	\$0	0	\$0	0	\$0
Total Labor (hrs \$)		99	\$5,493	64	\$3,170	67	\$3,437
ODCs							
Phone			\$30		\$0		\$50
Photocopy			\$20		\$0		\$150
Mail			\$100		\$400		\$60
Computer			\$150		\$0		\$400
CAD			\$0		\$0		\$450
WP			\$0		\$0		\$200
Travel			\$1,000		\$2,000		\$0
Per Diem			\$1,358		\$780		\$0
Eqpt. & Supplies			\$400		\$200		\$0
Total ODCs			\$3,058		\$3,380		\$1,310
Outside Services							
LTM/POC Well Installation Costs ^{a/}			\$12,650		\$0		\$0
Laboratory Fees ^{b/}			\$0	14 LTM, 3 qa/qc	\$6,885		\$0
Other: Maintain Institutional Controls			\$0		\$0		\$5,000
Total Outside Services			\$12,650		\$6,885		\$5,000

Proposal Estimate	Task 1	Task 2	Task 3
Labor	\$5,493	\$3,170	\$3,437
ODC's	\$3,058	\$3,380	\$1,310
Outside Services	\$12,650	\$6,885	\$5,000
Total by Task	\$21,201	\$13,435	\$9,747
Total Labor	\$12,100		
Total ODCs	\$7,748		
Total Outside Services	\$24,535		
Total Project	\$44,383		

Task 1: Install New LTM/POC Wells

Task 2: Sampling per Event

Task 3: Reporting and PM per Sampling Event

Alternative 3: Groundwater Extraction and Treatment System

Standard Rate Schedule

Billing Category Cost Code/(Billing Category)	Billing Rate	Design & Install Task Recovery System (hrs)	Design & Install Recovery System (\$)	System Monitoring/ Task 2 Maintenance (hrs) (weekly/1 yr.)(%)	System Monitoring/ Task 2 Maintenance (hrs) (weekly/1 yr.)(%)	Completion Task 3 Report (hrs)	Completion Task 3 Report (\$)
Word Processor 88/(15)	\$30	40	\$1,200	0	\$0	8	\$240
CADD Operator 58/(25)	\$47	140	\$6,580	0	\$0	16	\$752
Technician 42/(50)	\$40	450	\$18,000	400	\$16,000	16	\$640
Staff Level 16/(65)	\$57	450	\$25,650	100	\$5,700	64	\$3,648
Project Level 12/(70)	\$65	150	\$9,750	40	\$2,600	24	\$1,560
Senior Level 10/(80)	\$85	12	\$1,020	0	\$0	5	\$425
Principal 02/(85)	\$97	2	\$194	0	\$0	0	\$0
Total Labor (hrs \$)		1244	\$62,394	540	\$24,300	133	\$7,265
ODCs							
Phone			\$200		\$60		\$10
Photocopy			\$100		\$0		\$50
Mail			\$100		\$120		\$40
Computer			\$200		\$0		\$40
CAD			\$240		\$0		\$60
WP			\$100		\$0		\$40
Air fare/Travel (per trip) (two pers. one trip)	\$500	2	\$1,000	12	\$6,000		\$0
Vehicle (per day) (16 field, drill and install)	\$55	16	\$880	24	\$1,320		\$0
Per Diem (per day)	\$85	32	\$2,720	24	\$2,040		\$0
Eqpt. & Supplies	\$1,000	1	\$1,000		\$500		\$0
Total ODCs			\$6,540		\$10,040		\$240
Outside Services							
Well Installation			\$74,850		\$0		\$0
Soil Disposal			\$1,500		\$0		\$0
Equipment Costs			\$189,000		\$0		\$0
System Installation			\$57,080		\$0		\$0
Contingency (10 % of above services)			\$32,243		\$0		\$0
Analytical (initial 3 samp., 3 per mnth plus QC)	\$300	3	\$900	40	\$12,000		\$0
Local Subcontractor (maintenance)	\$1,000		\$0	12	\$12,000		\$0
Total Outside Services			\$355,573		\$24,000		\$0

Estimate	Task 1	Task 2	Task 3
Labor	\$62,394	\$24,300	\$7,265
ODC's	\$6,540	\$10,040	\$240
Outside Services	\$355,573	\$24,000	\$0
Total by Task	\$424,507	\$58,340	\$7,505
Total Labor	\$93,959		
Total ODCs	\$16,820		
Total Outside Services	\$379,573		
Total Project	\$490,352		

Task 1: Groundwater pump and treat system design and installation and report

Task 2: Monthly Site Time and Travel Costs (per year)

Task 3: Report Preparation

Alternative 2: Sparging

Standard Rate Schedule

Billing Category Cost Code/(Billing Category)	Billing Rate	Design & Install Sparge System		System Monitoring/ Maintenance		Completion Report	
		Task 1 (hrs)	Task 1 (\$)	Task 2 (hrs)	Task 2 (monthly / 1 yr)	Task 3 (hrs)	Task 3 (\$)
Word Processor 88/(15)	\$30	40	\$1,200	0	\$0	8	\$240
CADD Operator 58/(25)	\$47	150	\$7,050	0	\$0	8	\$376
Technician 42/(50)	\$40	300	\$12,000	400	\$16,000	16	\$640
Staff Level 16/(65)	\$57	300	\$17,100	100	\$5,700	40	\$2,280
Project Level 12/(70)	\$65	120	\$7,800	40	\$2,600	24	\$1,560
Senior Level 10/(80)	\$85	20	\$1,700	0	\$0	4	\$340
Principal 02/(85)	\$97	2	\$194	0	\$0	0	\$0
Total Labor (hrs \$)		932	\$47,044	540	\$24,300	100	\$5,436
ODCs							
Phone			\$200		\$60		\$10
Photocopy			\$100		\$0		\$50
Mail			\$100		\$120		\$40
Computer			\$200		\$0		\$40
CAD			\$240		\$0		\$60
WP			\$100		\$0		\$40
Air fare/Travel (per trip) (2 per., pilot & install)	\$500	4	\$2,000	12	\$6,000		\$0
Vehicle (per day) (22 days, pilot and install)	\$55	22	\$1,210	24	\$1,320		\$0
Per Diem (per day)	\$85	44	\$3,740	24	\$2,040		\$0
Eqpt. & Supplies	\$500	1	\$500	1	\$500		\$0
Total ODCs			\$8,390		\$10,040		\$240
Outside Services							
Well Installation			\$110,750		\$0		\$0
Disposal			\$2,000		\$0		\$0
Equipment Costs			\$10,500		\$0		\$0
System Installation			\$52,146		\$0		\$0
Contingency (10 % of above services)			\$17,540		\$0		\$0
Analytical (pilot test 5, 5 bimonthly plus QC)	\$300	10	\$3,000	35	\$10,500		\$0
Local Subcontractor (maintenance)	\$500	0	\$0	12	\$6,000		\$0
Carbon	\$500	0	\$0	0	\$0		\$0
Total Outside Services			\$195,936		\$16,500		\$0

Estimate	Task 1	Task 2	Task 3
Labor	\$47,044	\$24,300	\$5,436
ODC's	\$8,390	\$10,040	\$240
Outside Services	\$195,936	\$16,500	\$0
Total by Task	\$251,370	\$50,840	\$5,676
Total Labor	\$76,780		
Total ODCs	\$18,670		
Total Outside Services	\$212,436		
Total Project	\$307,886		

Task 1: SVE/Sparge system deisgn and installation and report

Task 2: Monthly Site Time and Travel Costs (per year)

Task 3: Report Preparation

Columbus AFB Backup Calculations

Alternatives 1, 2 and 3: Long-term Monitoring

Fisc calculations		Cost calculations					
		Description	Unit	Qty.	Unit Price	Subtotal	Total
New LTM wells:		Well Installation					\$ 11,500
Number of wells:	6	Mobilization	ea	1	\$ 2,000	\$ 2,000	
Depth each:	25 ft	Well Installation	ln ft	150	\$ 50	\$ 7,500	
		Soil Disposal	drum	20	\$ 100	\$ 2,000	
		Subtotal	-	-	-		\$ 11,500
		Contingency	ls	10%	\$ 11,500	\$ 1,150	\$ 1,150
		TOTAL					\$ 12,650

Columbus AFB Backup Calculations

Alternative 2: Sparge System							
Misc calculations		Cost calculations					
		Description	Unit	Qty.	Unit Price	Subtotal	Total Source (If applicable)
Number of vent/sparge wells:		Well Installation					\$ 110,750
Number of sparge wells: 45 x 30 ft		Mobilization	ea	2	\$ 1,500	\$ 3,000	Assuming 2 x mobile, one for pilot test Assumes no surface completion Estimate Estimate
Number of SVE wells: 0 x 15 ft		Well Installation	ln ft	1,350	\$ 75	\$ 101,250	
		Vapor mon. pts.	ea	5	\$ 1,000	\$ 5,000	
		PID and misc equi	day	12	\$ 125	\$ 1,500	
Disposal Fees							\$ 2,000
Soil Disposal		Soil Disposal	drum	20	\$ 100	\$ 2,000	Assuming non-hazardous
Equipment Costs							\$ 10,500
Trench Volume/Area		Equipment Costs					Skid-mounted Estimate Estimate Assume 2 x 55 gallon drums in series
Width: 1 ft		SVE blower/syste	ea	-	\$ 10,000	\$ -	
Depth: 3.5 ft		Sparge blower	ea	1	\$ 4,500	\$ 4,500	
Length: 950 ft		Electronics & PLC	ea	2	\$ 2,500	\$ 5,000	
Volume: 3,325 cf		Valves, gauges, ho	ls	1	\$ 1,000	\$ 1,000	
		Carbon	ea	-	\$ 1,000	\$ -	
123 cy		System Installation					\$ 52,146
Surface Area: 950 sf		Mob/Demob	ea	1	\$1,500	\$ 1,500	Estimate
106 sy		Trenching	cy	123	\$5.05	\$ 622	Means 022 254 0050
		Pipe laying	ln ft	950	\$13.05	\$ 12,398	Means 151 701 0550/026 686 2800
		Backfill	cy	123	\$17.20	\$ 2,118	Means 022 204 0600
		Compaction	cy	123	\$5.10	\$ 628	Means 022 204 0600
		Pavement Base	sy	106	\$5.25	\$ -	Means 022 308 0100
		Reseeding	sy	106	\$ 2	\$ 202	Means 029 304 0310
		Piping	lf	950	\$9.30	\$ 8,835	Means 151 551 1880
		Mechanical	man hr	40	\$ 39	\$ 1,553	Means Q-1 crew
		Electrical	ls	1	\$ 4,000	\$ 4,000	Estimate for electrician
		Electrical supply	ls	1	\$ 10,000	\$ 10,000	Estimate to provide power supply
		Slab	cy	3	\$97.00	\$ 291	Means 033 130 4700
		Building	ls	1	\$10,000	\$ 10,000	Estimate, (residential area)
		Subtotal	-	-	-	\$ 175,396	
		Contingency	ls	10%	\$ 175,396	\$ 17,540	
		TOTAL				\$ 192,936	

Columbus AFB Backup Calculations

Alternative 3: Groundwater Extraction System

Misc calculations			Cost calculations					Total	Source (If applicable)
			Description	Unit	Qty.	Unit Price	Subtotal		
Number of recovery wells			Well Installation					\$ 74,850	
10-inch recovery wells	8 x 55	ft	Mobilization	ea	1	\$ 2,000	\$ 2,000		Assuming 2 x mobe , one for pilot test
			Well Installation	ln ft	440	\$ 140	\$ 61,600		Includes well devel., screen, steel case.
			Add. monitor. pts.	ea	5	\$ 2,000	\$ 10,000		Estimate
			PID and misc equi	day	10	\$ 125	\$ 1,250		Estimate
Disposal								\$ 1,500	
Soil Disposal			Soil Disposal	drum	15	\$ 100	\$ 1,500		Assuming non-hazardous
Trench Volume/Area			Equipment Costs					\$ 189,000	
Width:	1	ft	Submersible pump	ea	8	\$ 2,500	\$ 20,000		Estimate
Depth:	3.5	ft	Air Stripper	ea	1	\$ 160,000	\$ 160,000		Estimate, 1800 gpm
Length:	550	ft	Electronics & PLC	ea	1	\$ 7,500	\$ 7,500		Estimate
Volume:	1,925	cf	Valves, gauges, ho	ls	1	\$ 1,500	\$ 1,500		Estimate
	71	cy							
Surface Area:	550	sf	System Installation					\$ 57,080	
	61	sy	Mob/Demob	ea	1	\$1,500	\$ 1,500		Estimate
			Trenching	cy	71	\$5.05	\$ 360		Means 022 254 0050
			Pipe laying	ln ft	550	\$13.05	\$ 7,178		Means 151 701 0550/026 686 2800
			Well vault boxes	ea	8	\$1,200	\$ 9,600		Estimate, concrete with spring cover
			Backfill	cy	71	\$17.20	\$ 1,226		Means 022 204 0600
			Compaction	cy	71	\$5.10	\$ 364		Means 022 204 0600
			Pavement Base	sy	61	\$5.25	-		Means 022 308 0100
			Reseeding	sy	61	\$ 2	\$ 117		Means 029 304 0310
			Piping	lf	550	\$9.30	\$ 5,115		Means 151 551 1880
			Mechanical	man hr	60	\$ 39	\$ 2,330		Means Q-1 crew
			Electrical	ls	1	\$ 4,000	\$ 4,000		Estimate for electrician
			Electrical supply	ls	1	\$ 10,000	\$ 10,000		Estimate to provide power supply
			Slab	cy	3	\$97.00	\$ 291		Means 033 130 4700
			Building	ls	1	\$15,000	\$ 15,000		Estimate, (needed for residen.area)
			Subtotal	-	-	-		\$ 322,430	
			Contingency	ls	10%	\$ 322,430	\$ 32,243	\$ 32,243	
			TOTAL					\$ 354,673	